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## PROTECTIVE RESEMBLANCE IN ANIMALS.

By R. LYDEKKER, B.A.Cantab.

THAT the colours of animals tend to assimilate themselves to the natural surroundings of the animals themselves is a fact which has been long known in natural history; and it is, indeed, one which is self-apparent to every sportsman and to every traveller in the wilder regions of the globe. For instance, everyone is probably aware that desert-haunting animals, like lions, gazelles, wild asses, jerboas, and many species of birds, generally have a uniform sandy-coloured coat, which renders them at a short distance almost or completely invisible in their native wastes. Then, again, every English sportsman knows how completely the coloration of the partridge and the hare assimilates with that of the stubble or ploughed fields in which they are wont to lie; while the mottled blacks and browns of the woodcock and snipe accord so exactly with the hues of decaying leaves and grass that the inexperienced eye will often fail to detect a wounded bird even when lying close to the feet, and scarcely anyone can distinguish the living birds when on the ground. The brilliant vertical orange and black stripes of the tiger and zebra, when seen in a menagerie or a museum, do not strike us as resembling anything in inanimate nature. In its native jungle, largely composed of upright yellow stems of tall grasses, between which are narrow intervals of deep black shade, the colour of the tiger is, however, admirably suited to its surroundings; and it is stated that the stripes of the zebra are arranged in such proportions as exactly to match the pale hue of arid ground by moonlight, so that on such occasions these animals are absolutely invisible even at very short distances. We hardly need refer to the white colour of polar animals, such as bears, ermines, foxes, hares, &c., as the most perfect example of this kind of protective coloration; and numerous other examples will at once present themselves to the reader.

Well known as are these comparatively simple instances of protective resemblances, there are, however, others of a more striking nature, where the animal either resembles the form of some inanimate object, or that of some other kind of animal which has especial means of protection; and since these resemblances are less generally known, they will form the subject of the present article. The term "protective resemblance" is generally applied to those instances where the animal resembles more or less closely an inanimate object, and thus renders itself inconspicuous; while the instances where one animal assumes the appearance of another, and thereby becomes conspicuous, are classed under the term "mimicry." It will, however, be obvious that both these kinds of resemblances are near akin, and are far in advance of protective coloration, pure and simple, where no imitation of form takes place. We shall first mention some instances of the imitation of the forms of inanimate objects by animals, and then refer to those cases where other animals are the objects of imitation.

Some of the best examples of what we shall take leave to call inanimate mimicry are to be found among insects, and we shall take our first case from among the butterflies. All are probably aware that a large number of these insects, such as our common peacock and tortoiseshell butterflies, while brilliantly coloured on the upper surfaces of their wings, have the under surfaces of the wings of a dull, sombre hue; and most of us have doubtless been almost startled at the suddenness with which one of these gaudy creatures seems to vanish altogether when it settles on dark ground or the rough bark of a tree, and at once closes its wings. Here, then, we have an instance of ordinary protective coloration, without any attempts of mimicry of form. There is, however, a peculiar group of butterflies allied to our own purple emperor, inhabiting Northern India and the Malayan region, which have gone far beyond this simple kind of protective resemblance, and actually imitate the form of leaves growing on their native branches. These butterflies (scientifically known as *Callima*), one of which is figured in the accompanying cut, have the upper surface of the wings brilliantly marked with orange, their front wings terminating in a sharp point externally, and the hind ones in a "tail," after the fashion of our swallow-tailed butterflies. Between the sharp point of the front and the tail of the hind wing there runs on the under surface a curved line, from which smaller lines are given off to the edges of the wings. When this butterfly settles on the stem of a plant bearing pointed leaves and closes its wings, the points and tails of the same of course come into exact opposition; and since the tail of the wings is closely applied to the stem of the plant it appears exactly as though it were the stalk of a leaf, the midrib and veins of which are exactly imitated by the lines on the under surface of the wings; while the apex of the leaf is formed by the opposed points of the front wings. So exact is the resemblance of the butterfly when in this position to a faded leaf, that, as Mr. Wallace tells us, it deceives the eye even when gazing full upon it;

The Leaf-Butterfly. (After Wallace.) *

and without actually seeing the insect settle upon the spot it is absolutely impossible to find it. To increase the delusion, no two individuals of these insects are precisely alike on the under surface; while many of them have little black patches, or dots, exactly resembling the dark fungous growths so often found on decaying leaves. Fortunately for the reader who desires to verify this extraordinary instance of inanimate mimicry, a case is now exhibited in the central hall of the Natural History Museum with several of these insects attached to a bough with faded leaves, and it is curious to watch the visitors to this case and see how often they fail to distinguish all the butterflies from the leaves which they imitate.

The next best instance of inanimate mimicry among insects occurs in the so-called stick- and leaf-insects, which are allied to our grass-hoppers and cockroaches. The stick-insects, of which some are found in Southern Europe, have long, slender bodies and limbs, of a dark colour, and so exactly resemble dry sticks that it is almost impossible to distinguish between the one and the other. To increase the resemblance, these insects when at rest have the habit of placing their legs unsymmetrically. On the other hand, the leaf-insects, or "walking leaves," of India, both in colour and form, so exactly simulate green leaves that they may be passed dozens of times without attracting attention. All the legs of these curious creatures are furnished with irregular flat expansions looking precisely like bitten leaves; while the head and fore part of the body forms a kind of stalk expanding behind into a broad and flattened abdomen, covered by the horny wings which are veined and netted so as to form an almost exact imitation of a leaf.

We might cite many other instances of inanimate mimicry among insects, but we must pass on to show that this phenomenon is by no means confined to this group of animals. Perhaps we should scarcely expect to find this kind of mimicry in such a comparatively highly organized a creature as a fish; yet there is a group of fishes, familiar to those who have kept aquaria, under the name of sea-horses, in which it is exhibited in its full perfection. The ordinary sea-horse attaches itself to a sea-weed or some other object by curling its tail tightly round it; and all these fishes have the habit of anchoring themselves by their tails in some way or another. In all of them the hard, horny body is furnished with a number of prominent ridges and spines; but in one, a peculiar group from the Australian seas, these spines attain an enormous development, many of them being prolonged into irregular filaments or streamers of skin, which are especially developed throughout the long and slender tail. As these streamers float in the water they so exactly resemble both in colour and shape the particular kind of sea-weed to which these fishes are in the habit of attaching themselves, that the whole creature seems but part and parcel of the fucus; so that when on the sea-bottom it must be impossible for any carnivorous rover to distinguish between the animal and the vegetable.

One more instance of this kind of mimicry, and we must close this portion of our subject. This example is taken from the mammalian, or highest class of animals, and, although not such a perfect imitation of form as those we have already mentioned, is very remarkable as occurring so high up in the animal kingdom. Most of our readers are probably acquainted, at least by name, with those lowly South American mammals known as sloths. These animals are inhabitants of the great forest regions of that continent, and are of a sombre greyish colour, very like that of the gnarled and lichen-clad boughs, from beneath which they are wont to hang back-downwards. Not only, however, is their general colour like that of a lichen-covered branch, but their coarse grey hairs actually develop a growth of lichens upon themselves to complete the resemblance to their surroundings. It is, indeed, clear that the long grey coat of the sloths has been produced for the sole purpose of this protective mimicry, for when this is removed there is found beneath an under coat of softer fur marked by yellow and black stripes, which may be pretty confidently regarded as the original coloration of these animals.

We have now to consider animate, or true mimicry, in which one animal imitates the form, and generally the habits, of another in order to participate in the immunity from foes enjoyed by the latter, owing either to the possession of some formidable weapon, or to its unpalatable nature as food. In all cases of this kind of mimicry it is essential that the mimicked animal should be numerically far more abundant than the mimicker, as otherwise predatory creatures would soon learn that the inocuous and palatable animal was more likely to be captured than the harmful one. Undoubted cases of true mimicry are most common among insects, and it is to these alone that our observations will be confined. We may also observe that mimicking insects, as a rule, mimic other insects, although it has been considered that some large caterpillars mimic snakes, and certain moths certainly imitate birds.

We will first refer to some excellent and well-marked instances of mimicry which occur among the insects of our own country. Most of us are probably familiar with those large

* We are indebted to Messrs. Macmillan & Co. for this figure.

hairy brown flies which may be seen in autumn creeping in a sleepy sort of manner about the windows of houses, and are commonly known as drone-flies, and scientifically as *Eristalis*. These insects, although true flies, with only a single pair of wings, are so like bees (in which, it need scarcely be said, there are two pairs of wings) that it is very difficult to persuade some persons that they are not really members of that group of insects. Their resemblance to the latter is increased by their similar habits, more especially their bee-like buzz; and there is no doubt whatever but that they are mistaken by birds for bees, and thereby enjoy an immunity not granted to ordinary flies.

Again, the gaudy flies marked with bold bands of black and yellow which are so common on fine summer days in gardens, and are known as wasp-flies (*Syrphus*), take their name from their resemblance to wasps, which in some species is so close as to make it difficult to convince people that they are not really wasps.

Less common than the above-mentioned flies are the beautiful British insects known as clear-winged hawk-moths. Some of these, named hornet clear-wings (*Sphecia*), so exactly resemble large wasps or hornets that they would deceive nine persons out of ten who are not entomologists. Moreover, they have precisely the same habits as hornets, and when caught will actually curl up their bodies in a wasp-like manner as if about to sting, although they are perfectly harmless. Less complete is the resemblance of other clear-wings—hence known as bee clear-wings—to humble-bees. These insects, as has been well observed, are, however, very important, as proving that their mimicry is an acquired character, since when they first emerge from the chrysalis their wings are thinly covered with the well-known minute scales characteristic of ordinary moths, these scales soon falling off and leaving the wings perfectly transparent. This indicates that the ancestors of the clear-wings had wings like other moths.

In all the foregoing instances the mimicking insects imitate various members of the Hymenopterous order; but we have now to notice a case where a moth imitates a bird so completely as to deceive even the best observers when the two creatures are on the wing together. The moths in which this kind of mimicry occurs take their name of humming-bird hawk-moths from this very circumstance, and are represented by a species not very uncommon in some parts of our own country. So close is the resemblance between these moths and humming-birds that Mr. Bates tells us that, when on the Amazons, he has actually shot specimens of the former in mistake for the latter; and the natives of these regions are firmly convinced that both are of the same species. The extended proboscis of the moth does duty for the slender beak of the bird, while the end of the body of the former is expanded into a kind of brush which imitates the tail of the bird. Humming-birds are, of course, not seized as prey by insectivorous birds, and hence the moths escape their natural enemies from their resemblance to the humming-birds. In our own country, where there are no humming-birds, it is somewhat difficult to see what advantage its bird-like form is to the humming-bird hawk-moth, and possibly its comparative rarity may be due to the absence of the birds it mimics.

We come now to those very remarkable cases of mimicry, as exemplified among the butterflies, where one species mimics one or even more members of the same order, owing to the immunity of the latter from the attacks of birds on account of their unpalatable taste. That the mimicked butterflies are protected by their unpleasant taste has been amply proved by their being offered over and over again to birds, by whom they are as invariably rejected. Their immunity from attack is further proved by their slow flight, and by the bright colouring of the under sides of their wings, so that they have no means of concealing themselves. Most of these mimicked butterflies are found in tropical and sub-tropical regions, and belong to the great families known as *Danaiidæ* and *Heliconidæ*. In America these butterflies are usually mimicked by various species of the family of "whites" (*Pieridæ*), which, as we all know in the case of our common cabbage butterfly, are eagerly sought by birds; and the difference of the mimicking species from an ordinary white by the assumption of the bright colours of the Danaids is so great that nobody but an entomologist would imagine for a moment that it even belonged to the same family. It is, moreover, curious that there is one instance where two species of Heliconids inhabiting adjacent regions are respectively mimicked by two varieties of one and the same species of "white."

Stranger even than this, however, is the case of certain South African swallow-tailed butterflies. In this group, as a rule, both sexes are alike, and furnished with the characteristic "tails"; but in one South African species the females entirely lose their appendages, and alter their coloration and the form of their wings so as to mimic not only one, but actually three distinct species of Danaids. Here, then, we have an instance in which a single species of butterfly exists under four totally distinct forms; viz., the typical swallow-tailed male, and the three varieties of tailless females respectively mimicking the three Danaids. No one would have the faintest idea that the three females belonged to the same family, let alone to the same genus and species, as the male; while the three varieties of the female would be assigned without hesitation to as many distinct species. That female butterflies are more often protected by mimicry than the males is a fact which may probably be explained by their extreme importance to the race, and also from the circumstance that when heavily laden with eggs they are more likely to fall a prey to birds than are the lighter males.

A great deal more might be said on the subject of mimicry in butterflies, but we must pass on to our last instance of this feature, which is, perhaps, the most peculiar of all. In this case the mimicked insect belongs to that peculiar group of ants which have the curious habit of carrying in their mouth a leaf which extends backwards over their bodies, and apparently acts as a kind of shade. Now, in British Guiana, there is an insect allied to the cicadas and other bugs, in which the leaf borne by these ants is represented by the thin and laterally flattened body of the creature, which is so compressed that it does not exceed a leaf in thickness, while its jagged upper border simulates well enough the irregular contour of the leaf carried by the ants, of which the borders are generally gnawed by the bearers. Although the legs and lower part of the body of this most curious insect are reddish in colour, the leaf-like upper part of the body has assumed a green hue exactly resembling that of the ant-borne leaves. In a drove of cooshie ants, as the leaf-bearers are called, the mimicking insect is distinguishable solely by its somewhat inferior size; this difference is not, however, sufficiently great to attract the attention of birds, which have learnt by experience that the cooshies are by no means palatable morsels.

It would be beyond the scope of the present article to enter upon the difficult question of the means whereby these mimetic resemblances, whether to animate or inanimate objects, have been produced; but sufficient has been said to show that an amount of interest lies in the

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subject, and those whose interest has thus been aroused may perhaps have the good fortune to discover new and unsuspected instances of one or other of these types of protective resemblances.

## SOME PRACTICAL APPLICATIONS OF ELECTRICITY.

By J. J. STEWART.

(*Continued from page* 226, *Vol. XIV.*)

### IV.—INCANDESCENCE LAMPS.

THERE are two important types of lamp used in illumination by means of electricity—that of arc lamps, described shortly in my last paper, and that in which the immediate source of light takes the form of a thread of carbon raised to a white heat. In describing this second form of lamp it may lead to clearness to consider first, as an example, that special kind of incandescence lamp known as Swan's; for the difference between the various adaptations of glowing carbon to lighting purposes is one of detail merely, the main principle being the same in all.

Mr. Swan tells us that for long it had seemed to him that if ever the electric light was to become generally useful it would be through some application of the incandescence of carbon; and he made a long series of careful experiments in his endeavour to hit upon some method whereby incandescent carbon might be rendered an illuminating agent which would last and give a permanent light.

It is now thirty years since Mr. Swan performed the following experiment in his investigation of this subject. He caused a number of strips of card and paper to be surrounded by charcoal and then put in a crucible, which was afterwards raised to a white heat in a pottery kiln. These pieces of cardboard were in the form of an arch half an inch in length and a quarter of an inch across. They were changed to strips of carbon by the intense heat of the furnace, and their ends were fixed in square carbon blocks by means of small clamps. When these carbon threads, thus prepared, were placed in glass vessels and the air exhausted by means of an air pump, Mr. Swan was delighted to see the threads brighten up with a ruddy glow whenever an electric current from a voltaic battery of 40 or 50 cells was sent through them, and he felt confident that all that was needed was a stronger current in order that they should give out a brilliant white light. Swan believed that this was the first occasion on which carbonized paper was made use of in the construction of an incandescence electric lamp. At that time (somewhere about the year 1860) the cheapest source of the electric current was the voltaic battery, but, as in the case of arc lamps, the introduction of the dynamo machine with its powerful currents gave a great impetus to the attempt to utilize glowing carbon.

After Swan's earliest experiments the matter rested, so far as he was concerned, for seventeen years, till about the year 1877, when he was again led to take up the subject. Not only was there a difficulty at first in getting a strong current at small cost, but the limits attainable in producing a high vacuum were nothing like what they became after the introduction of the Sprengel air pump. The durability of the incandescent filament of carbon depends very much on the perfection of the vacuum obtained in its containing globe; because in the presence of the oxygen of the residual air the carbon consumes away more or less rapidly. Crookes had shown, in his beautiful experiments with the radiometer, how good a vacuum could be attained by means of the Sprengel pump, and Mr. Swan adopted this method of producing a high vacuum in his glass globes. In conjunction with Mr. Stearn, who had had a large experience in the use of the Sprengel pump, he mounted some of his carbonized paper filaments in the globes provided for them, and then exhausted the globes of air as completely as possible. As showing the importance of attention to minute details, it is interesting to note that in this case it was found that the carbon absorbed some of the air around it while it was cold, and then gave out this air when it was heated strongly by the passage of the current, thus partially destroying the carefully prepared vacuum. The device of heating the carbon threads strongly by passing through them a current *while the process of exhaustion was going on* was made use of, and thus the air entangled in the carbon was driven out before the globes were finally sealed. It is by careful attention to such minute particulars as these, which less earnest investigators might have overlooked, that the present brilliant success in electric lighting has been reached. The wires leading the current to the lamp are in connection with supporting clips, and great care has to be used in order to make a good contact between the threads of carbon and the metallic clip, and such an one as shall be able to resist the high temperature to which the junction is exposed. In Swan's lamps the carbons were thickened at their ends, and, in some of the first trials, electrotyping and hard soldering of the ends of the carbon to platinum was applied.

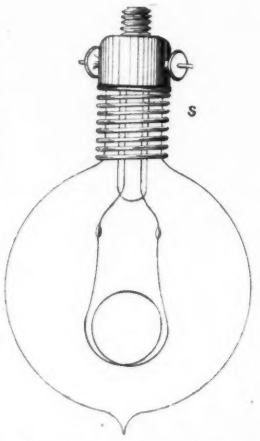


FIG. 1.—Shows the Swan Lamp connected up and ready for use. The spiral spring *s* (shown apart from the lamp in Fig. 2) is compressed round the neck of the globe, and holds it with a firm yet flexible grip, the electrical contact being perfect, and the whole connection leaving little to be desired in point of neatness and efficiency.

In 1878 Edison took up the subject of incandescence electric lighting. After unsuccessfully attempting to make a durable conductor out of a mixture composed of infusible earth with carbon and metallic substances, he proceeded to use platinum, still without success. Afterwards he went on, with his characteristic unflagging energy, to try "carbon wires," as he discovered that a thread of ordinary sewing cotton, when properly carbonized, remained unbroken for a long time, even at extremely high temperatures, when it was placed in a bulb exhausted of air to such an extent that the pressure was reduced to one-millionth of an atmosphere. In some of his trial lamps he employed filaments made from Bristol board, but ultimately he chose filaments of bamboo as most suitable for the "Edison lamps."

There were experimenters in this field of incandescence lighting before either Swan or Edison took up the subject. M. Jobard, in 1838, suggested the use of carbon, placed in a vacuum, as a conductor, and this idea was carried out twenty years later, in 1858. Early workers were King, in our own country, in 1845, and Starr in America. Mr. Mattieu Williams was working with King and Starr, and he says: "We had no difficulty in obtain-

ing a splendid and perfectly steady light. We used platinum and alloys of platinum and iridium, and then tried a multitude of forms of carbon, including burnt cane."

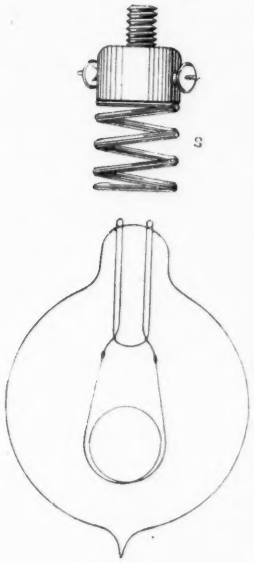

Fig. 2.

These attempts, however, were not successful in leading to any practical application on a large scale, and to Swan and Edison belongs the credit of first demonstrating the capability of this method of incandescence of carbon in high vacua to give permanent and satisfactory results in actual practice.

The following are the principal details in the structure of the glow lamps of Swan and Edison, and the points in which they differ. In the recent types of Swan lamp an organized material such as crochet cotton is taken; this is treated with acid, whereby the cotton fibres are reduced to a gummy consistency before they are carbonized. Edison starts with bamboo fibre, and has fixed on this substance because it possesses a definite structural form. The shape of the carbon in Edison's lamp is a long arch, or a carbon thread simply twisted back to run parallel to itself. Swan's form differs in having in the course of the carbon a spiral of one turn whose diameter is half an inch.

The thickness of Swan's carbon is about 0·25 millimetres, *i.e.*, $\frac{1}{100}$ of an inch. Edison's 16-candle power filament is oblong in cross section, the sides of the oblong being 0·1 and 0·2 millimetres, *i.e.*, $\frac{1}{250}$ and $\frac{1}{125}$ inches.

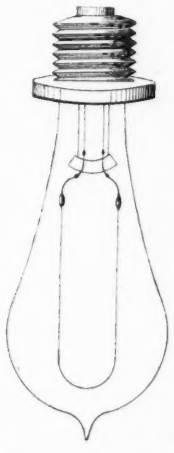

Fig. 3. — Edison's Lamp.

The filaments of carbonized bamboo in Edison's lamp are prepared thus:— The canes got from the plant, which are tubular in form, are prepared first of all by machinery devised for the purpose, so that a large number of uniform pieces is rapidly obtained. The canes are first of all sawn into suitable lengths. Each of these pieces is then split down its centre, and two half tubes are thus got; both of these are again divided into three strips, the hard outer rind containing silica is removed, and the stripped pieces are shaved down so as to produce a flat and straight strip of uniform thickness throughout its length; these strips are then cut so as to be of the same length. After a set of similar fibres has been thus prepared, they are placed in blocks and cut so that their final shape is a narrow strip of bamboo with enlargements at each end, by means of which they are joined to the connecting wires. The fibres are next bent into the required form, that of a loop or horseshoe, and carbonized by being raised to a white heat in muffles placed in a furnace. Next they are electro-plated on to their platinum supports, this being done to ensure a thoroughly good contact, and then placed in their containing bulbs. These latter are repeatedly exhausted of air, whilst the fibre contained in them is again and again raised to a very high temperature (by the passage of an electric current) and allowed to cool down between its successive heatings. By this process the air or any occluded gas is got rid of, and besides this the fibres are subjected to such a severe test that only those which are quite sound can survive it, and in the end a fibre suited to the purpose in view and capable of long endurance is obtained.

The *efficiency* of different lamps is compared by finding the quantity of energy used up per candle power produced. This energy, which is consumed in the lamp, is equal to the difference of potential at its terminals multiplied into the current passing through it, and is generally expressed in volt-ampères, *i.e.*, the product of the potential (or electric pressure) expressed in the practical units or volts, multiplied into the strength of the current in ampères. Thus the "efficiency" of a glow lamp depends on the pressure at which it is worked and the strength of the current which circulates through it. The length of time which such a lamp lasts (or its "life") and its efficiency are intimately connected. The overlooking of this fact has led in the past to numerous misleading or partial statements, even in technical journals. To know the quality and goodness of a lamp we must be acquainted, not only with the number of hours it has existed while giving out light, but also with the amount of energy which has been employed in producing this light. As an example, I may take an instance given by Sir David Salomons. He says he has hundreds of lamps which have run over 3000 hours, and he attributes the long life of his lamps to his method of obtaining constant electro-motive force round his circuit. The pressure (or electro-motive force) in this instance is kept between the limits of 98 volts and 100 volts, and the results have exceeded expectations. Here on the average it has been found that 16-candle power Edison-Swan lamps, meant to be worked at a pressure of 100 volts, give a light whose intensity is equal to 15 candles at 98 volts and 17 candles at 100 volts.

For practical purposes, another important factor comes in, and one which determines which lamp shall be used in a given case, and this is the *cost* of the production of the energy required. This last factor varies with circumstances, the sources of power being so different—*e.g.*, waterfalls used to drive dynamo machines, secondary batteries previously charged up, primary batteries, &c.

The *commercial efficiency* of a lamp depends not only on the amount of energy required to work it, but also on the cost of this energy.

If we take a fixed quantity of gas and compare the result—*first*, when it is used to drive a gas engine which works a dynamo machine, and thus produces a current through a set of incandescence lamps, or, *secondly*, when the gas is burned at once, and thus used directly as an illuminant, it is found that the light-giving efficiency of the electrical method is three times that of combustion. But the cost of the electrical method is at present greater on account of the first expense, and then the maintenance of the gas engine and dynamo.

The advantages of using electricity as a means of lighting in mines are very noticeable. The only suitable lamps for such a purpose are those which are portable. Hence, if electricity is to be used at all, the lamps employed must be incandescence lamps. When these are made use of, the work becomes more sure, more regular, and more rapid, and it is even claimed that the moral nature of the miners is improved when they work surrounded by the brighter and more agreeable light of electric glow lamps. The

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problem of the electric lighting of mines has not yet been thoroughly solved, but success seems to lie in the direction of a portable glow lamp worked by a secondary battery. This may be made very light, and the extra cost, which at the present moment is unavoidable, is more than saved by the preservation of life and limb and the altogether more satisfactory condition of the miner. Swan has invented an indicator which he attaches to his portable lamp. This depends on the observed fact that a red-hot platinum wire glows more brightly in an atmosphere charged with fire-damp than in pure air.

For intensity of illumination glow lamps can never compete with arc lamps, but the advantage of the former lamp is that they may be distributed at will, and concentration in one place, which is often a drawback, is avoided.

## BEE PARASITES.—I.

By E. A. BUTLER.

THERE is no other order of insects that has made such strides in the cultivation of architectural and constructive talent as the Hymenoptera; and consequently, whenever the subject of insect skill is under discussion, the majority of the illustrations are sure to be taken from this order. Whether as excavators, stone-masons, carpenters, or workers in wax or in paper, many members of the Hymenoptera have made their mark in the world, and bees, ants, and wasps in particular have attained a high degree of excellence in one or other of these crafts. While the majority of insects are to a great extent wanderers on the face of the earth, having no definite spot with which their fortunes are inseparably associated, dwelling nowhere in particular, but, like nomads, living from hand to mouth, and prepared to take up temporary quarters wherever they may chance to find themselves at the end of a day's wanderings, most of the above-named have what may be more or less correctly called homes, fixed places of abode which they have carefully selected for the rearing of their families as well as for their own private residence, places in which they may be expected to be more or less continuously found, and upon which they often expend a vast deal of labour to fit them for the double purpose of a retreat for themselves and a shelter for their brood. The sense of proprietorship is thus developed, and its accompanying anxieties and responsibilities have to be faced, even if, as is often the case, only for the short period of a single summer season. The establishment of a home, and the accumulation of stores therein, creates a temptation to less thrifty beings to profit by the industry and skill that have achieved these results, and burglary and swindling thus become professions amongst insects as well as amongst mankind. It is in the existence of this, so to speak, landed proprietorship amongst the Hymenoptera, this elaborate construction of dwellings and advance in social habits, together with the dangers and risks consequent thereupon, that is to be found the reason for the numerous remarkable relations into which so many of them are brought with other insects. We have already seen good examples of this in the ants, and we now propose to take other illustrations of a somewhat different character from a kindred race. It is not with the hive bee that we shall concern ourselves; this insect is so artificialized through its close alliance with man, that it has no chance of furnishing such good examples as those species exhibit which have only their own cleverness and courage, unbacked by the assistance of superior beings, to depend upon in endeavouring to maintain their place in the world. Of these wild bees we have many British species, some of which—the humble bees—are social, while the rest are solitary. But both sections are alike subject to the attacks of thievish depredators, derived either from their own order, or from other groups, and the reason for the parasitism therefore is to be found, not so much in the development of the social instinct, as might perhaps have been expected from the example of the ants, as in the effects produced by architectural skill and forethought, the securing of a safe retreat and supplies of food, which serve as prizes to tempt the cupidity and appeal to the indolence of the unthrifty.

Bees are subject to the attacks chiefly of other bees and of flies, and the parasites in some cases closely resemble their hosts, but in others are quite unlike them. We may first consider the parasitism of the social bees. Apart from the hive bees, all British social bees belong to one genus, called *Bombus*. The word was coined by the ancient Greeks in imitation of the deep bass humming which these bees produce during flight, whence also their English names of humble or bumble bees. Some fifteen species of these insects are now reckoned as inhabiting the British Isles, and, like other social insects, they exist in three forms—males, females, and workers. Great differences in size appear in these. The females are by far the largest, and are the well-known great, heavy, loud-humming creatures that fly swiftly straight forward in a "bee line," or hum in a deep self-satisfied bass, on a sunny spring day, round the sallow bloom. The males are considerably smaller, and are generally very differently coloured from their mates, being either more brilliant or more variegated. The neuters are the smallest of all, and are usually more or less like miniature reproductions of the females, several sizes smaller. Their nests are not very numerous in individuals, and each owes its foundation to the exertions in early spring of a hibernated female, who is thus both the foundress and the widowed mother of the colony, her spouse having died the previous autumn. The first members of the colony are workers, and the grubs which produce them are fed with pollen and honey collected by the great queen mother. When they arrive at maturity, they undertake the work of the nest, providing food for the later members of the family. As the season advances, males and females are produced, which are destined to become the founders of next year's colonies, their mating taking place in the autumn, though the progeny is not produced till the next season. Such, in very brief outline, is the life-history of a *Bombus*. Now, there is a genus called *Psithyrus* or *Apathus*, superficially very much like *Bombus*, so much so in some species that a novice would be sure to regard them as the same insect. These are the parasites, and their economy is quite unlike that of the *Bombi*. They enter the nests of the latter, deposit their eggs there, and leave their offspring to be cared for and fed by the legitimate owners of the nest, while they themselves do nothing towards their maintenance. No labours, therefore, either in the collection of food, or in the construction or repair of nests, devolve upon them, and there is thus no need for workers as distinct from males and females, and hence we find that in this genus no such things as workers are known, there being only the two sexes as in solitary insects.

Further, as pollen collecting, to provide food for the young, is one of the chief occupations of the industrious bees, these parasites, having no need to undertake this labour, are unprovided with the necessary apparatus. The most important part of this apparatus consists of what is called the "corbicula" (little basket) (Fig. 1). The tibiæ of the hind legs of the female and worker

*Bombi* are broad and flat or slightly concave, and shining; no hairs grow on this shining surface, though all the rest of the body is densely covered, but a closely set row of long, stiff, curved hairs runs along each side of it, sloping backwards and slightly outwards, but not enough to prevent them from making a sort of trough-like enclosure, of which the polished surface of the tibia forms the bottom; this is the corbicula, or receptacle, in which the pollen is packed, after having been collected by means of the dense brushes of hairs which cover the body. The tibia of the males is sometimes nearly bare and polished, but its surface is somewhat convex, and the brushes of hairs at the sides spread out almost on a level with its surface, or are indiscriminately arranged, so that no enclosure is made. Now the *Psithyri* have no such arrangement as above detailed; the hind tibiæ of the female are not broadened, their outer surface is decidedly convex, not smooth and polished, but covered scantily with hairs, and no erect rows of bristles fringe their side margins, and those of the male are quite similar; these peculiarities alone are sufficient to distinguish these parasitic bees from their industrious hosts. The *Psithyri*, also, are not so densely covered with hairs as the *Bombi*; certain parts of the upper surface of the abdomen especially have the hairs short and thinly scattered, so that the bare shining skin can easily be seen through them, whereas the *Bombi* would have these parts covered completely with dense bands of fur, and scarcely any trace of the skin beneath would be visible.

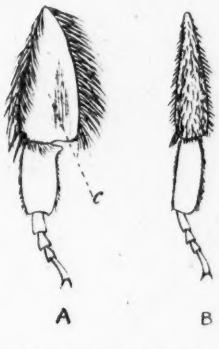


FIG. 1.—Left hind tibia of (A) *Bombus*, (B) *Psithyrus*. *c*, Corbicula.

Now, as these *Psithyri* in their larval condition are nourished at the expense of the working *Bombi*, and are therefore a constant drain on the resources of the nest, it is difficult to believe that the parasites would, if recognized, be tolerated in the nest unless they contributed in some way to the well-being of the establishment; and if they were at all conspicuously different in appearance from the true owners, it would be a risky matter to enter the nest, more particularly as they are connected almost entirely with those *Bombi* that are underground builders, and these are the most fiery-tempered of the genus. As they do not, so far as is known, contribute in any way to the advantage of the colony they are associated with, it is easy to conjecture a reason for the remarkably close imitation they exhibit of the appearance of their hosts, a disguise so complete that they are able to pass in and out of the nests entirely without molestation, a disguise, too, which appears to extend to the larvæ, for it is difficult to believe that the workers would consciously waste their time and efforts upon foundlings which in no way serve to strengthen or otherwise aid their own race. There is a curious point in connection with this imitative dress of the parasites that is worth notice. It is obvious that it is only the females and workers that any invaders would have to fear, for the males have no sting, and have therefore no means of attack except their jaws; the greatest safety would seem therefore to be obtainable by the parasites becoming undistinguishable from the dangerous groups of their hosts, while resemblance to the harmless males would not be so important. Hence we find that not only do the females of the *Psithyri* ape the colours of their female and worker hosts, but the males do so as well, thus becoming quite different from the same sex in the *Bombi*. Take, for example, the common red-tailed humble bee (*B. lapidarius*). The females and workers of this insect are generally black all over except the last three segments of the abdomen, which are bright red, highly suggestive of their fiery temper. But the male has, in addition to its red tail, a yellow-haired face, and a broad yellow band in the front of the thorax. Now the male of the *Psithyrus* which accompanies this species (*P. rupestris*) has no yellow, but, like the female, is usually coloured only black and red, with at most a few greyish patches at the sides. The resemblance between the two females, however, is not quite so close as a description of their bodies alone would lead us to imagine, for the wings of the guest are much darker than those of the host. The resemblance between the other species of *Psithyri* and their hosts is perhaps not quite so close as in the case indicated above, but still sufficiently so to cause them to be confounded on a casual glance; examination of the hind legs would at once show their distinctness. In size they usually compare with the male and female *Bombi*, and are therefore larger than the workers. There may be another reason for the imitation of the female and worker *Bombi*, rather than of the males, which may be found in the fact that the males much less frequently visit the nest after they have once left it, and therefore the parasites would become more noticeable if coloured like these occasional visitors, than when resembling such constant residents as the workers.

The nests of the red-tailed bee (*B. lapidarius*), are frequented by another parasite whose relations to its hosts are much more serious. This is a two-winged (dipterous) fly, called *Volucella bombylans*. It is something like a large bluebottle in shape, and about the size of the worker bees, which it imitates in colour, being black-bodied and red-tailed. Entering the nests it lays its eggs there, and the maggots issuing from these devour the larvæ of the bees, sometimes destroying almost the whole brood. It seems marvellous that these depredations are not checked by the bees themselves, which apparently have the remedy in their own hands, since they might easily sting the larvæ to death, even if the parents had escaped notice. One almost feels disposed to conclude that they fail to discriminate between the fly maggots and their own larvæ, though there is a considerable difference between the two. A similar apparent obtuseness of perception is exhibited with regard to the flies themselves; for the differences between the two-winged and light-bodied fly, and the four-winged and much more substantial bee are sufficiently obvious, notwithstanding the disguise; and it is scarcely credible that if they did recognise the flies, and divine in the least degree the object of their visit, they would allow them to enter the nest unmolested. On the other hand, if they really do not distinguish between the flies and their own comrades, the necessity for the imitative dress seems to be rather less obvious. It is generally maintained that bees recognise their comrades belonging to the same nest, but several observers have suggested that this is by smell rather than by form or colour, in which case strange flies would seem to be placed at a disadvantage, since they evidently would not possess the smell peculiar to the nest they might wish to enter. Sir John Lubbock's well-known experiments serve to show that the colour sense is well developed in bees, but this does not imply an equal power of perceiving details of form, and hence it may possibly be sufficient for the parasites to show a black and red body in order that they may pass muster. The risk run by these flies, however, on the supposition that the bees really do object to the destruction of their offspring, and would fight in their defence if they knew

of the danger to which they are exposed, must be greater than in the case of the parasitic bees already referred to, since not only is theirs the less venial offence, but if it came to a fight, the *Psithyri* have their stings to defend themselves with, and would no doubt give a tolerably good account of themselves, while the flies have absolutely no means of defence when once their disguise is penetrated, and would be quite at the mercy of their foes.

*Volucella bombylans* does not confine its attentions to the red-tailed bee, but visits the nests of the yellow-tailed ones as well, and it is a remarkable fact that the colour of the parasite varies with that of its host. Those individuals that live with the red-tailed bee are themselves red-tailed, but those that come from the nests of the yellow-tailed ones themselves partake of this style of ornamentation, and show no red at all; so different in fact are these varieties that it is difficult to believe that they represent the same species. Other species of the same genus also occur in bees' nests, but in these cases there is not the resemblance between parasite and host that obtains in the instance already cited, and yet the flies seem to be able to elude observation and carry out their piratical enterprises in safety and with success. These flies also inhabit wasps' nests, where they destroy the brood; in this case there is certainly no attempt to imitate the colours of the hosts, but then, according to Sir John Lubbock, wasps have the colour sense less well developed than bees, and therefore possibly any detailed imitation might only be thrown away upon them.

Another parasite to which some humble bees are a prey, is an insect not very commonly found in this country, and sometimes called a solitary ant. Its scientific name is *Mutilla Europæa* (Fig. 2). It consists of males and females only, the former of which are winged as usual, but the latter entirely apterous. The thorax is bright red, and the abdomen, the ground colour of which is black, is prettily banded with thin lines of glittering yellow hairs. Thus it is quite unlike the bees in shape and appearance, and the female looks more like an extremely large and very strong and stout ant. This insect is carnivorous in its habits, and its larvæ devour those of the bees, sometimes, in countries where they are plentiful, destroying almost the whole brood; in this country they are never sufficiently numerous to do this. That they are neither essential parasites of the *Bombi*, nor entirely confined to those insects is clear from the facts that though the *Bombi* are extremely common insects with us, the *Mutillæ* are rather rare, and there must be hundreds of nests of bees from which they are absent, and that, on the other hand, *Mutillæ* either of this species or others closely allied are often abundant in countries where *Bombus* is either rare or does not exist at all. Other insects also may be found in the nests of social bees, such as little beetles and mites. The former come in for the sake of the wax, with which the honey-pots of the bees are made, and the latter partly for this too, but also to attack the bees themselves, to whose bodies they cling, and whose juices they suck, exhibiting thus a third type of parasitism. In the other instances we had the parasites attacking either the food of the young bees, or the larvæ themselves; now we have parasites which subsist upon the perfect insects.

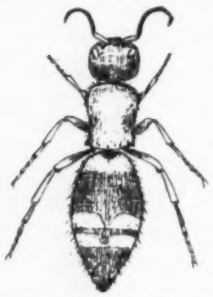

FIG. 2.—*Mutilla Europæa*, a parasite of humble bees, magnified three diameters.

(*To be continued.*)

## THE DISTRIBUTION OF SUNSPOTS IN SOLAR LATITUDE.

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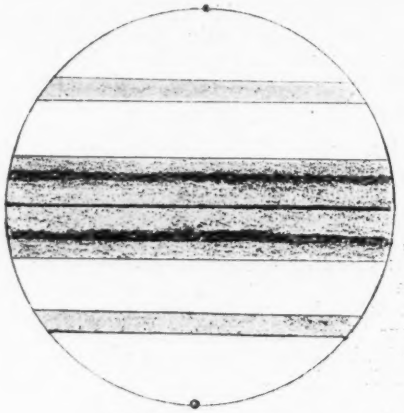
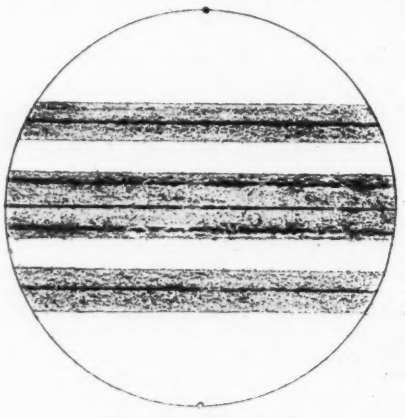
TO the attentive observer of solar phenomena, the vast size, beautiful detail, and changes of form of the great group of February last did not constitute its only, perhaps not its chief claim to notice; and even its association with the great magnetic storm of February 12th, and with the appearance of auroræ, is scarcely of more importance than the feature to which I wish now to allude—I mean its drift in solar latitude.



Just before Minimum.

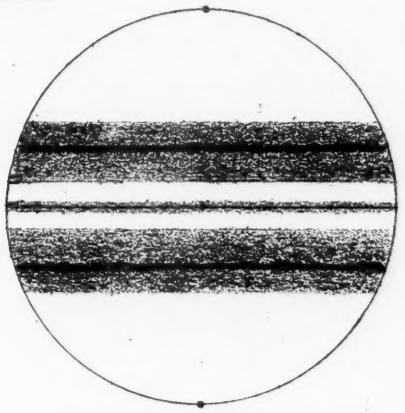
Briefly the history of this great outburst is as follows: A considerable group was observed in S. lat. 19° during November, 1891, and it was accompanied by two companion groups, which for the sake of distinction we will call B and C, denominating the principal group as A. B was in S. lat. 19°, and C in S. lat. 11°. During December C was not observed, but A and B were; the former in S. lat. 20°, the latter in S. lat. 19°. During this rotation B became the more considerable group, and in the next



Just after Minimum.

rotation, that of January, 1892, it was seen alone; this time in S. lat. 25°. During February, when it attained its greatest development, its latitude was 27·5°, and in March, when it was much smaller in area, it was a little

further south still, viz., in S. lat. 28·5°. It had shown, therefore, a steady movement away from the equator from November, when it lay in S. lat. 19°, to March—the month when it was last seen—when it was very nearly 10° further south.

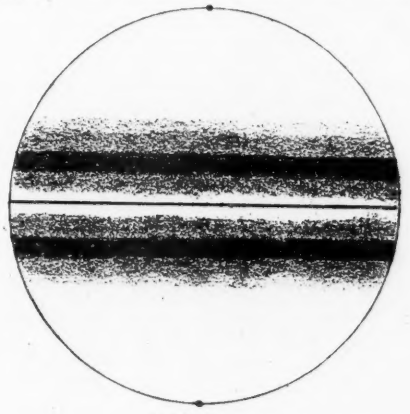


Before Maximum.

We have to bear in mind that this implies a drift of more than 70,000 miles in less than four months—indeed, in one month of the four, the drift amounted to 46,000 miles—and that it concerned an object which, whatever its nature, showed on the average an area of 600 millions of square miles, and a maximum area of six times that amount.

As the February group was the greatest in area of all those observed during the period covered by the Greenwich record, so it stands out as pre-eminent in its drift. But other groups also have shown a great and remarkable drift; indeed, a large and active group is almost sure to display some motion of the kind, and in many instances the evolutions performed by a large group are of the most complicated character.

If, however, we confine ourselves to the great groups to which we have already drawn special attention in earlier papers, viz., those of April and November, 1882,



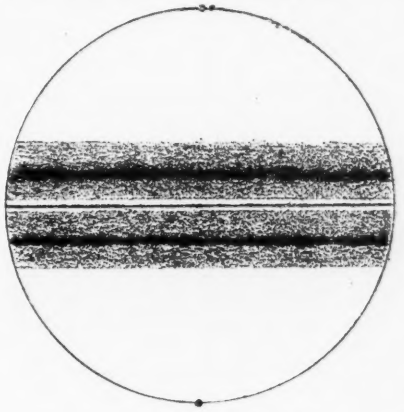
At Maximum.

we find that the April group showed a drift of $6\frac{1}{3}°$ in latitude during a single month; slightly greater than the maximum drift of the recent spot, but as the group of April, 1882, was only observed during three rotations, it did not show that long persistency in southward motion which the later group has done. The second great group of April, 1882, was only observed during one rotation. The third great group of 1882, that of November, showed little or no persistent drift, remaining almost stationary for the greater part of the three months during which it was under observation, but displaying a rather rapid movement towards the equator during the last four or five days of its existence.

A yet more curious feature of this drift in latitude, which is frequently to be noted, is the tendency to return to the latitude from which the group first started. A single example may illustrate the point.

The group of August 2nd, 1889, formed in S. lat. 21°, and steadily moved towards the equator, being last seen in its first rotation in S. lat. 20°. When it was seen at the east limb again on August 27th, its latitude was 19°. It steadily moved upwards during its appearance, and had nearly regained its old position of latitude 20° before it passed out of view at the west limb. During its third and last appearance it oscillated between 21·5° and 20·5°, finally disappearing when in the last-named latitude.

Drift in latitude is therefore not at all an uncommon feature of sunspots, though drift to so large an extent as that shown by the great group of February last, viz., 10° in four months, is most exceptional. Yet such



After Maximum.

drift is not at all what we should have naturally expected. For there is a well-marked difference in the speed of rotation of the various zones of the solar surface. Spots on the equator, for instance, not only have an actual rate of speed higher than those north or south of them, but a more rapid angular motion; in other words, whilst a spot on the equator takes 25 days to complete a rotation, one in latitude 36° takes 27.

But curious as are these instances of motion in latitude in the case of specific groups, there is a far more curious phenomenon, akin to it, shown by sunspots as a whole—I mean the change in the latitudes affected by spots at various stages of the sunspot cycle.

Let us suppose that we are watching the sun during the period of decline after maximum; during such a time as that covered by the years 1886 and 1887, for example. What should we notice? In 1886 we should notice that spots were seen over the entire belt from 20° N. to 20° S., not a few lying quite close to the equator, their mean position in either hemisphere being about 10° of latitude; but that out of 128 separate groups only one, and that a very small one which lasted but two days, was seen further from the equator than lat. 20°. In 1887 the tendency was to approach the equator still closer. The mean latitude of the entire spotted area was 8·5°, and no single group attained a distance from the equator of

20°. Indeed, of 79 groups only four were as far from it as lat. 18°. Spots in their "teens" were becoming decidedly scarcer, whilst spots on or close to the equator were relatively more common.

It will be noticed that this change in position accompanied a marked decline in the numbers and areas of the groups. In 1886 there were 128 groups observed, and the average daily extent of the spotted area of the sun was 450 millions of square miles. In 1887, there were only 79 groups, and the average daily extent of the spotted area had shrunk to 210 millions of square miles. In 1888 the number of groups had gone down to 54, and the mean daily spotted area to just half what it had been the previous year; and this shrinkage had been caused for the most part by the disappearance of high latitude spots, so that the mean latitude of the spotted area was now only $7\frac{1}{3}°$. North of the equator, the only group that exceeded 10° in latitude lay in latitude 11°; in the southern hemisphere, which was the more active, there was one group at 12°, two at 13°, and one at 15°, but all the others were under 10°; so closely were such groups as still appeared huddled together towards the equator.

But on the last day but one of the year, one little faint insignificant spot broke out in quite a different region from these. True, it was gone before the morrow. Its mandate might have been like that of Macbeth's visions, to "come like shadows, so depart." But none the less, small, faint, and fleeting as it was, it was the harbinger of a mighty change in the general aspect of the sun.

The next year, 1889, showed a yet further decline in the solar activity. Only 32 groups were observed, and the mean daily spotted area was now only 90 millions of square miles; and during the first half of the year, so marked was the decay of the high latitude spots, that not one instance was observed of the mean position of a group exceeding 10°.

But on June 29th the harbinger spot of the previous December was followed by a second, quite as small and faint, and nearly as evanescent, for it lasted only two days, but in a higher latitude still, 40·3°. Other groups followed it. A group was seen in S. lat. 24° in July; a fine group in S. lat. 20° ran its course during three several appearances, in August, September, and October; and in all, counting these three apparitions of this group as three different groups, twelve groups were seen with latitudes exceeding 20° during the last half of the year, whilst nine appeared in the equatorial region. The spots during the last six months of 1889 were therefore divided into three distinct zones—a northern zone, comprising spots with latitudes of 20° and upwards; an equatorial zone, embraced between latitudes 10° N. and S.; and a southern zone, with spots of latitude 20° and upwards. But the zone 10° to 20° on either side of the equator was wholly barren.

In 1890 the sun began to show clear signs of reviving activity. With this revival of activity came a further decline in the number and area of spots in the equatorial zone, and a very rapid increase in those of high latitude. Only four groups out of the fifty-five were found in the former region, and these were but small. With October, 1890, the old series practically came to an end, and since then the high latitude spots have held the entire field. Several groups have been seen between 30° and 35°, and two out of every three groups were situated in the 20° to 30° zones.

But as time goes on, these tend ever to seek lower and lower latitudes. In 1891 there were two spot zones, one north and the other south of the equator, and the equatorial region was entirely barren; but as the cycle progresses and as spots in positions as high as 28° or 30° become rarer, so spots close to the equator become more common, till at length the state of affairs will again be as it was in 1886 and 1887, and there will be practically but one spot zone, and that close to the equator.

We have, therefore, three phases of the spot-cycle. I. Before minimum; spots few and diminishing; one spot zone, viz., that close to the equator. II. After minimum; spots few but increasing; three spot zones, viz., an equatorial zone, and a zone of high latitude in either hemisphere, separated from the equatorial zone by a broad barren belt. III. At or near maximum; spots numerous; two spot zones, one north and one south of the equator, the equatorial region itself being entirely barren. It follows, then, that the two barren belts of the second period are on the average the most prolific for the cycle as a whole, for they become the seats of spot activity just at the time when sunspots are largest and most numerous.

There is, therefore, a steady and continuous tendency ever to seek lower and lower latitudes from the beginning of a cycle till its end. The first small and faint spots of the new cycle break out in the very highest latitudes attained. In this sense the new period begins at once with its utmost vigour, and during the years in which it runs its course is simply undergoing a continual decline. As to the numbers and areas of the spots, the case is very different. For some three years there is a most marvellous and rapid increase, followed by two or three years of great activity. Then comes a decline, which is, however, slower and less striking than the increase. Finally, for about a year, we have on the sun the last feeble relics of the old cycle, together with the first heralds of the new one. Or we may put it another way. The sunspot cycle is about eleven years on the average, but each particular spot-cycle takes about twelve years to entirely run its course, so that for a year the two cycles run concurrently.

The following little table will illustrate this for the last spot-cycle, that of 1879–1890:—

| Year. | Mean Daily Area. | Mean Distance from Equator of all Spots. | Year. | Mean Daily Area. | Mean Distance from Equator of all Spots. |
|---|---|---|---|---|---|
| 1879 | 54 | 23·57° | 1885 | 957 | 11·76° |
| 1880 | 491 | 19·80° | 1886 | 450 | 10·38° |
| 1881 | 861 | 18·21° | 1887 | 211 | 8·44° |
| 1882 | 1182 | 17·81° | 1888 | 105 | 7·39° |
| 1883 | 1363 | 13·04° | 1889 | 61 | 6·34° |
| 1884 | 1273 | 11·27° | 1890 | 6 | 7·14° |

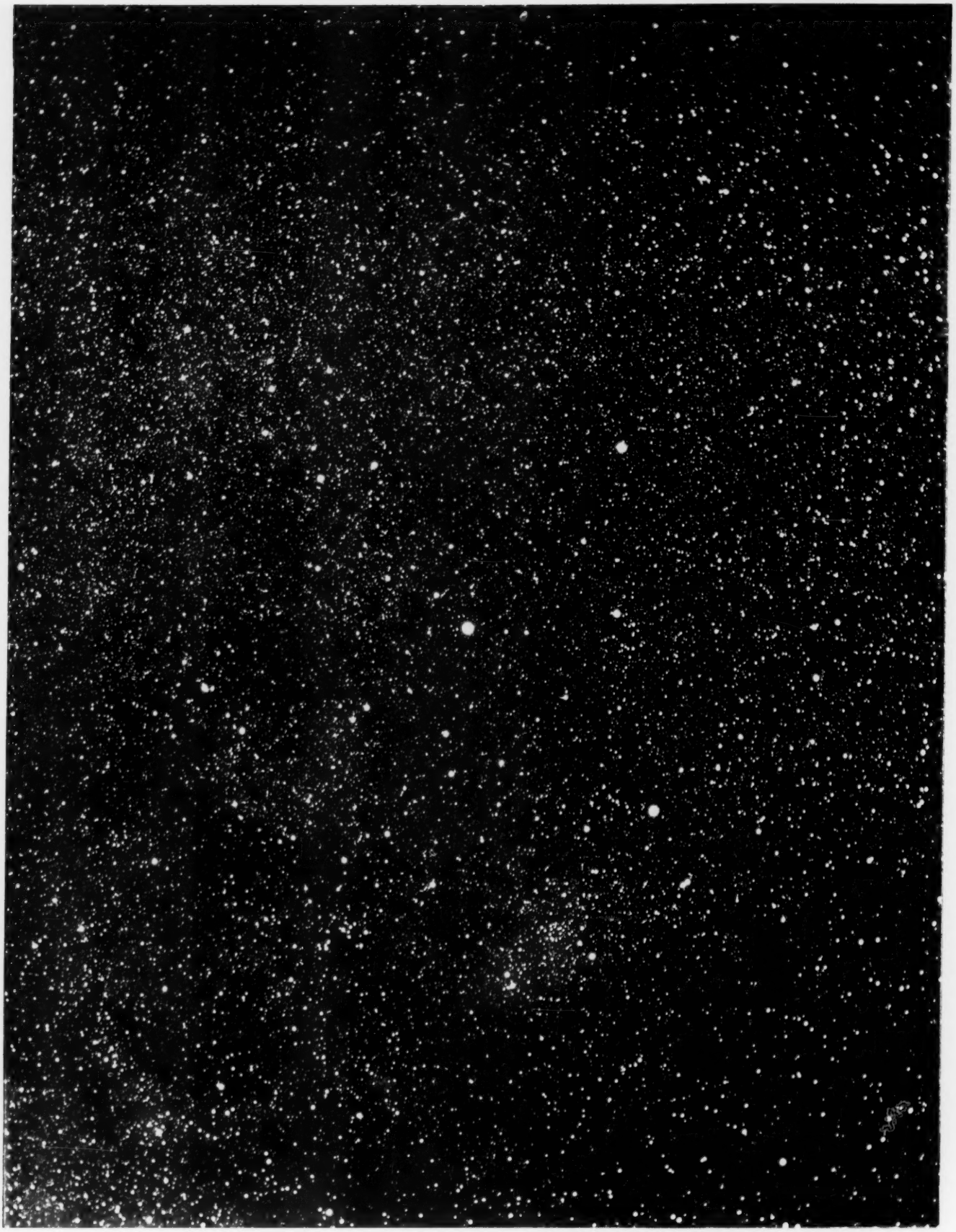
The mean area is expressed in millions of square miles, and for the years of overlapping, 1879, 1889, and 1890, only the spots proper to this cycle have been included.

This was no special behaviour of a single cycle. It is the usual typical behaviour. If we take the cycle 1856–1867, and divide it into periods of fifteen rotations on the average, we find the mean spot latitude of the successive periods will run as follows*:—32°, 26·7°, 21·3°, 17·8°, 17°, 14·2°, 12·1°, 10·4°, 10·3°, 9·2°, 8·2°, 8°. Of these twelve periods the first two were coincident with the last two periods of the earlier cycle, with mean latitudes 7·8° and 5°; and the last two, with the earliest periods of a new cycle, latitudes 31° and 22°. Similarly, this cycle, 1867–1878, ran from 31° and 22° to 22·6°, 18·3°, 16·2°, 13·8°, 11·2°, 11·4°, 10·3°, 9·2°, 7·0°, and 5·4°; and these last two periods again were coincident with the first two of the cycle of which we have already treated, that of 1878–1889, as the last two periods of that cycle in its turn were coincident with the first two of the cycle through which we are now passing.

* The figures are those of Dr. Spoerer (*Astr. Nach.*, No. 2565), who more than any other observer has brought these relations under the notice of astronomers.

XUM

North.



**THE REGION OF THE MILKY WAY ABOUT $\beta$ CYGNI.**

Enlarged from a Photograph taken by Dr. MAX WOLF, of Heidelberg, with a Kranz Aplanatic Camera of 5½ inches aperture and a focal length of 30½ inches; exposure 12 hours.

*The Automatic Engraving Company, Strode Road, Willesden Green.*

The accompanying diagrams, in which an attempt is made to represent the manner of spot distribution at different periods of the cycle, will perhaps set forth these changes more clearly than much description can do.

So strongly marked a relation must evidently be given great weight in any theory which we form as to the origin and nature of sunspots. Unfortunately, I cannot claim to have framed any such theory myself, and the only point I would urge is that these various relations—the sudden appearance of the spots of a new cycle in high latitudes, the persistent decline in latitude of the general spotted area as the cycle progresses, and the drift in latitude of individual groups—seem to me absolutely fatal to the idea, once popular, that the secret of solar disturbances lies without the sun; in the relative positions of the planets, for example, or in the fall of meteorites.

If this purely negative conclusion is felt to be disappointing, I cannot help it. I feel no mission myself to explain everything, but rather prefer to state the facts as I know them for others to explain. Yet it is no light matter in our progress towards truer theories that we should get rid of the false ones.

I think, therefore, we may settle ourselves that the secret of the sunspot problem lies below the solar surface, not above it; and the well-known fact, that outbreaks often recur in the same districts after considerable intervals of time, appears to me to strongly confirm it.

There is one other circumstance, in connection with this decline in latitude as the spot-cycle progresses, to which I should like to allude. Just as the increase in the number and size of spots after minimum does not proceed regularly, but by waves, one fortnight being rich in spots, and the next poor, and so on, oscillating to and fro, but the days without spots becoming ever fewer, and the days with spots both more numerous and richer, so it is with the decline in latitude. It proceeds in waves. Every fourth or fifth rotation there will be an effort to reach a higher level, a lift of one or two degrees, and then a gradual slipping back until a fresh effort brings another small lift, but a weaker one than the last. And so the cycle goes on; the decline is continual on the whole, but is broken and interrupted by these frequent little struggles to get back to a higher plane. One could almost fancy one saw a living being trying to maintain a losing battle with ever-declining strength. No doubt these minor oscillations proceed from a cause similar to that which gives rise to the great lift in latitude at the beginning of a new cycle, and it is in the attentive study of the laws according to which these changes occur that we may hope to unravel their meaning, and in so doing add to our knowledge of the constitution of the sun.

## WHAT IS A NEBULA?

By A. C. RANYARD.

THE plate which illustrates this paper has been made from a photograph kindly sent me by Dr. Max Wolf, of Heidelberg. It represents a region of the Milky Way not very distant from the regions represented in the plates published with the October and December numbers of KNOWLEDGE for last year.

The bright star near the centre of the plate is $\beta$ Cygni, a beautifully coloured double star well known to the possessors of small telescopes as a very easy test object. It is not shown as double in the plate because the photographic trace left by the two stars is a patch, or disc, more than a tenth of an inch in diameter, which corresponds to some seven or eight minutes of arc upon the heavens, while the two stars, though they form a pair which may be easily split by a good opera glass, are only 34″ apart—that is, on the scale of the plate their centres would be separated by a distance of only about $\frac{1}{150}$th of an inch. This minute separation, though not recognizable on the photograph, corresponds to a real distance in space which is so great that during the time in which man has been observing them no motion of one star about the other has been noted, though their colours would lead us to conclude that they are really associated. The larger star, which is of the third magnitude, shines with a golden yellow light, while the smaller star of the seventh magnitude is a beautiful azure blue, thus conforming to the general law that in coloured binaries the smaller star is always bluer than the larger one.

This plate of Dr. Max Wolf's, although it was exposed for twelve hours, does not show as much nebulosity as the plates of the regions around $\alpha$ Cygni and $\xi$ Cygni, published in the October and December numbers of KNOWLEDGE; but especially in the lower half of the plate there is a very distinct background of nebulosity, interrupted here and there by dark channels and dark prominence-like forms, associated with lines of small stars.

The nebulous background of the Milky Way is too faint to allow of its light being analysed with the spectroscope, but its whitish colour, as seen with the naked eye, seems to indicate that it does not belong to the type of nebula which gives bright lines or a gaseous spectrum.

About half the nebulæ that have been examined spectroscopically give a spectrum in which six or seven lines are fairly conspicuous. The three brightest of these lines are situated in the green,* and they give to this class of nebula a very distinct bottle-green tint that enables an observer with a large telescope to recognise one of these gaseous nebulæ at sight as differing from a white nebula, such as the nebula in Andromeda, which gives a continuous spectrum unmarked by any well-recognizable lines or bands.

The faint continuous spectrum of the white nebulæ is not crossed by any dark absorption lines such as we see in the spectra of the stars. If the light of these nebulæ were due to thinly scattered faint stars, too small to be individually visible, we might expect their combined light to give a faint spectrum crossed by dark absorption lines common to the spectra of the small stars. That such absorption lines are not visible in the spectra of the white nebulæ is *primâ facie* evidence that they do not consist of sparsely distributed bodies similar in constitution to the brighter stars.

It has been assumed that the greenish nebulæ which give bright line spectra are masses of incandescent or glowing gas; but such masses of gas, if quiescent in space, would be cooler on their outsides, and the outer cold layers would, according to the theory of exchanges, absorb the radiations given out by the glowing gas within. The bright line spectrum of these nebulæ seems always to be accompanied by a more or less faint background of continuous spectrum, such as would be given out by glowing solid or liquid particles, or by gas under pressure. Reasoning from first principles, it seems probable that a quiescent mass of hot gas cooling in space would give out a continuous spectrum from its lower regions, where it is under pressure, so that the free paths of its molecules are relatively short, and this faint continuous spectrum would, it seems probable, be channelled by dark lines in places

* All the gaseous nebulæ give approximately the same type of spectrum. The brightest line is situated in the green region, at wave-length 500·4; the next in brightness is also in the green, at wave-length 495·8; and the next in brightness is the well-known bluish-green F line of the hydrogen spectrum situated at wave-length 486·1.

XUM

corresponding to the wave-lengths absorbed by the outer cool gas. If, however, a part of the gaseous constituents condensed into liquid or solid particles in the outer and cooler regions of the nebula, we should have the above conditions complicated by the action of the glowing particles on the molecules of the uncondensed vapours surrounding them.

The extreme faintness of the nebular glow is a fact that must not be lost sight of in seeking for a possible explanation of the facts observed. If the nebular matter glowed with a millionth part of the brightness of the solar photosphere, the nebulæ would give us far more light than they do.

Let us assume with Prof. E. C. Pickering that the stellar magnitude of our sun is −25·5—in other words, that our sun gives about forty thousand million times as much light as a star of the first magnitude. According to this estimate, the sun would need to be removed to a distance where its diameter would appear to subtend an angle of only ·00964 of a second of arc to reduce its light to equality with that of a star of the first magnitude. A nebula which subtends a minute in diameter and gives the light of a star of the eigth magnitude gives $\frac{1}{9\,3\,1}$th part of the light of a star of the first magnitude, while its diameter is more than six thousand times as great as the diameter which our sun would appear to have at a distance where its light would appear equivalent to that of a star of the first magnitude; consequently the solar photosphere must, area for area, be more than twenty-two thousand million times as bright as such a nebula.

According to Prof. Langley, the sun's photosphere* is 5300 times brighter than the molten metal in a Bessemer "converter"; consequently, the nebula must glow with a light which corresponds to less than one millionth of the brightness of white-hot iron. Perhaps one might compare the brightness of the nebula with the faint glow of the trail left by a large meteor on entering our air. Such trails seem to be due to glowing red-hot particles. The vapour driven off from the meteor is for an instant intensely luminous. It is no doubt under great pressure, and rapidly expands, driving back the cold upper air. In expanding, it cools till the greater part of the vapour is precipitated into a glowing mist, which having no elasticity, and not being able to do work by driving back the surrounding air, can only cool by radiation. In this condition the trail from a large meteor sometimes remains faintly glowing for half an hour. The evidence seems to show that at first the trail gives out bright lines in addition to a continuous spectrum. The study of such trails may throw much light on the constitution of the nebulæ.

## Letters.

[The Editor does not hold himself responsible for the opinions or statements of correspondents.]

### THE EVOLUTION OF DOUBLE STARS.

*To the Editor of* KNOWLEDGE.

SIR,—I am not sure that I quite follow the theory of Mr. See on the evolution of binary stars, but I think generally he maintains that these stars owe their highly eccentric orbits to the fact that their masses are much more nearly equal than, for instance, those of the sun and Jupiter. Assuming this to be the case, we would expect the orbits of very unequal double stars to be much less eccentric than those of nearly equal ones; and although the mass of a star may not correspond with its magnitude, there must on an average be a pretty close relation between them. I accordingly examined the stars in Mr. Gore's catalogue, taking in each instance the latest orbit as founded on a larger number of observations than its predecessors. I classed as equal the binaries whose magnitudes did not differ by more than one-half, and as unequal those whose difference was not less than two magnitudes. The following is the result of my comparison:—

| Unequal Binaries. | | Equal Binaries. | |
|---|---|---|---|
| Star. | Eccentricity. | Star. | Eccentricity. |
| $\eta$ Cassiopeiæ | 0·6244 | $p$ Eridani | 0.674 |
| 40 Eridani | 0·1362 | $\Sigma$ 1037 | 0·632 |
| O$\Sigma$ 149 | 0·460 | $\Sigma$ 3121 | 0.3086 |
| Sirius | 0 4055 | O$\Sigma$ 215 | 0·4346 |
| $\alpha$ Centauri | 0·5443 | O$\Sigma$ 234 | 0·3629 |
| $\gamma$ Coronæ B. | 0·3483 | $\gamma$ Virginis | 0·8715 |
| $\lambda$ Ophiuchi | 0·4424 | 42 Comæ | 0·480 |
| $\zeta$ Herculis | 0·463 | $\eta$ Coronæ B. | 0·2667 |
| 70 Ophiuchi | 0·4994 | O$\Sigma$ 298 | 0·5836 |
| 99 Herculis | 0·7928 | $\Sigma$ 2091$^2$ | 0·7352 |
| $\delta$ Cygni | 0·327 | $\mu$ Draconis | 0·493 |
| $\beta$ Delphini | 0·0962 | $\zeta$ Sagittarii | 0·1698 |
| $\tau$ Cygni | 0·3475 | $\gamma$ Coronæ Aust. | 0·4244 |
| O$\Sigma$ 489 | 0·343 | $\zeta$ Aquarii | 0·6000 |
| 85 Pegasi | 0·35 | $\Sigma$ 1819 | 0·3052 |
| 25 Can. Ven. | 0·7221 | $\Sigma$ 2173 | 0·1349 |
| | | $\xi$ Scorpii | 0·0768 |

No striking contrast will be found here, nor do either set differ much in eccentricity from those where the difference in magnitude between the components ranges between one-half and two. The eccentricities, however, are in most cases very uncertain. Thus in Mr. Gore's table those for Sirius range from 0·4055 (Mr. Gore's) to 0·945 (Mr. Mann's), for Castor from 0·300 to 0·797, for $\alpha$ Centauri from 0·5260 to 0·9689, $\sigma$ Coronæ Borealis 0·3088 to 0·7515, $\lambda$ Ophiuchi 0·4424 to 0·8191, $\tau$ Ophiuchi 0·0375 to 0.6055, &c. The following, however, are agreed in either by all computers, or a large majority: $\gamma$ Virginis (equal) 0·85 to 0·9, $\xi$ Ursæ Majoris (medium) 0·38 to 0·43, $\lambda$ Ophiuchi (unequal) 0·44 to 0·5, $\zeta$ Herculis (unequal) 0·43 to 0·48, 70 Ophiuchi (unequal) 0·4 to 0·5, $\gamma$ Coronæ Borealis (medium) 0·34 to 0·39, $\Sigma$ 3121 (equal) 0·26 to 0·38. The result, on the whole, does not seem to me to favour the theory of tidal evolution.

Truly yours,

W. H. S. MONCK.

P.S.—In the solar system the rule appears to be that the orbits of the smallest bodies are the most eccentric. It may be worth noticing that the equal pairs (with computed orbits) appear to have in all cases spectra of the second or solar type.

[By courtesy of the Editor I have been permitted to read Mr. Monck's criticism, and will say in reply that he slightly mistakes my meaning. Large relative masses imply the development of large eccentricities only in so far as these masses imply large initial moments of momentum of axial rotation. For upon the moments of momentum of axial rotation depends the increase in the orbital momentum and mean distance, with which the increase of the eccentricity is so intimately connected. Unless the sum of the moments of momentum of axial rotation of the stars of a system is greater when the stars are equal than when unequal, it does not follow that the eccentricity would become higher. According to theory, therefore, we must not conclude that (for example) $\eta$ Cassiopeiæ (masses 1 to 4) should have a smaller eccentricity than $\alpha$ Centauri (masses equal). It is also to be borne in mind that the eccentricity will depend

* See Prof. C. A. Young's "Sun," p. 245.

upon the age of the system. For a more complete discussion of these questions I must refer Mr. Monck to my paper on the "Evolution of the Double Star Systems," which will appear in November, and will probably remove any doubt that may remain as to the correctness of the theory of double star evolution. Numerical calculation shows that tidal friction is an amply sufficient cause to account for the great eccentricities, and also that the eccentricity developed under different conditions would be very different. It is not, therefore, surprising that eccentricities of every kind exist, as this could have been predicted from theory.

Very faithfully yours,

Zimmer Straza, Berlin. T. J. J. SEE.]

## A MEAN-TIME SUNDIAL.

MOST people know that an ordinary sundial does not give clock time—sometimes the dial time is fast and sometimes it is slow as compared with clock time; for sundial days are not, like ordinary days, all of equal length. When the earth is in the part of its orbit which lies nearest to the sun, it moves faster, and describes a greater angle about the sun in twenty-four hours than when it is in the part of its orbit furthest from the sun; consequently, when the earth is in perihelion the solar day exceeds the sidereal day by more than the average amount, and the shadow of the gnomon comes round again to twelve o'clock a little later than when the earth is in aphelion.

The mean time shown by ordinary clocks is based upon the division of a mean day, which corresponds to the mean or average length of the day as measured by the sundial shadow at different parts of the year. The clock time corresponds to the dial time which would be shown by a "fictitious" or "mean" sun moving uniformly in the equator at the same average rate as that of the real sun in the ecliptic.

The "equation of time" corresponds to the difference of time which would be shown on a dial by the *real* sun and the *mean* sun. It is reckoned as *plus* when the sundial is slower than the clock, and *minus* when it is faster. It is the correction which must be applied to the ordinary dial time in order to obtain mean time, and it sometimes amounts to more than sixteen minutes. Although a great deal of ingenuity and thought has for centuries been expended upon the construction of sundials, I am not aware that any one of the old dial makers ever succeeded in contriving a dial to show mean time. The difficulty has, however, at last been overcome in a very simple manner by Major-General J. R. Oliver, who has devised a gnomon which practically makes its own correction for the equation of time.

The peculiarity of the instrument is that the time is indicated, not by the shadow of a straight edge, as in the old sundials, but by the point where an equatorial circular line is cut by the edge of the shadow of a curved surface, the curvature of which is so arranged with respect to the sun's distance above or below the equator as to compensate for the "equation of time."

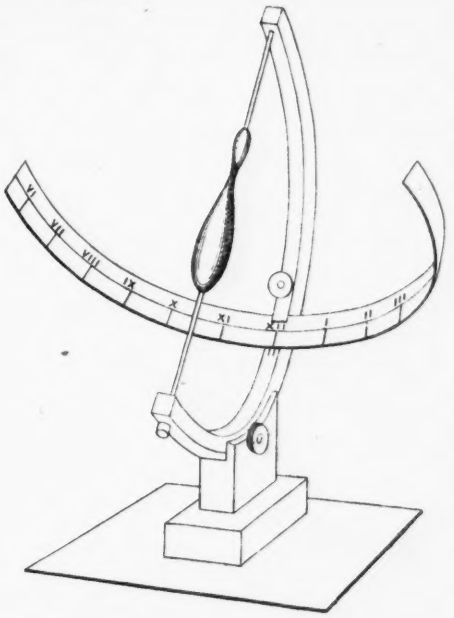
The instrument, says Major-General Oliver, is a universal one, and consists of a meridianal semi-circle, the diameter of which is an axis carrying the curved gnomon, and an equatorial circular arc. The latter has engraved upon its concave surface a graduated line, on which are marked the hours and their subdivisions. There is a screw for clamping the meridianal arc at the proper position for any given latitude, and another clamp for adjusting the equatorial arc.

The dial not only indicates local mean time, but by a very simple adjustment may be set so as to show any required standard time. Thus it might be set at Plymouth to indicate Greenwich time.

Strictly speaking, there ought to be two gnomons, one to be used from June to December, and the other from December to June; but by adopting a gnomon of mean contour the greatest error introduced at any time is only about one minute, an amount not more than the unavoidable one due to the softness of the edge of the shadow.

Four times a year the equation of time vanishes, and the gnomon would then intersect its own axis. To allow for the necessary thickness of the latter, a slight adjustment of the hour circle is necessary at these times.

Although the invention is little more than a scientific toy so far as England is concerned, it is believed that it would be of great use in countries where sunshine is plentiful and means of regulating the time are scarce. South Africa, South America, Australia, and India may be adduced as instances. In India, for example, there are numerous up-country stations at a distance from any railway, where there are practically no means of correcting clocks and watches.




The figure shows the form of the dial devised by Major-General Oliver. A comparatively cheap mean-time sundial might, I would suggest, be easily made by amateurs, with a glass globe such as is used for keeping gold-fish. A divided circle would need to be etched or painted round its greatest girth, and the gnomon might be made of a knitting needle centrally placed and carrying a piece of wood or gun-metal turned to scale from a curve which may be laid down from a table (such as one finds in *Whittaker*) giving the equation of time for each day of the year. The knitting needle should be passed centrally through a cork or bung in the mouth of the globe, and into a block fixed by marine glue at the bottom of the globe; and the globe must then be tipped on one side and supported in a stand so that the knitting needle is parallel to the earth's axis. From December 25th to April 15th, when according to the almanacs the sun is after the clock, one reads the time from the following edge of the shadow. When the equation of time has vanished and the

Sun is before the clock, one reads from the preceding edge of the shadow of the club shaped bob on the gnomon, at the place where its shadow cuts the hour line.

One of Major-General Oliver's dials may be seen at Messrs. Negretti and Zambra's shop on the Holborn Viaduct.

A. C. RANYARD.

## THE FEEDING OF A PLANT.

By J. PENTLAND SMITH, M.A., B.Sc., *Lecturer on Botany at the Horticultural College, Swanley.*

PLANTS take in their food material from two sources—the soil and the air. The manner of its absorption depends upon the constitution of the plant under consideration. So far as regards the nourishing process, the vegetable kingdom may be divided into two large classes—the first including all those plants which possess green colouring matter, the second those in which this green substance is conspicuous by its absence. Our present consideration will be the feeding of green plants, and we will preface our remarks thereon by referring generally to the structure of these, and specially to that of the higher members of the series.

The green plant detachment numbers in its ranks the most simple structures and the most complex organisms. The simplest are composed of a single sac or bag, which we call a *cell*, and the highest members of the series are built up of an aggregation of cells. "The true meaning of the word 'cell' may be quite clear to but few, the less so since biologists themselves, even now, hold and discuss the most different opinions upon it. To many, the cell is always an independent living being, which sometimes exists for itself alone, and sometimes 'becomes joined with' other millions of its like, in order to form a cell-colony, or, as Hæckel has named it for the plant particularly, a cell-republic. To others, again, cell-formation is a phenomenon very general, it is true, in organic life, but still only of secondary significance; at all events, it is merely one of the numerous expressions of the formative forces which reside in all matter, in the highest degree, however, in organic matter."*

Much has been written on the subject of the plant structure, and the subject itself is an exceedingly interesting one to the anatomist; but to the general reader, at least, anatomy, apart from physiology, is a dry study. The two departments ought always to go hand in hand.

In the lowest plants, and in the lowest animals, a single cell performs all the life-functions. As we proceed higher in the scale of organization we notice that differentiation takes place, and continues until, in the highest forms, a complex series of tissues exists, each fitted for the performance of a definite work. In both kingdoms a mass of protoplasm (πρωτος, first, and πλασμα, form) constitutes the simplest cell. The composition and function of protoplasm we will discuss presently; it suffices in the meantime to note that the lowest cell does not have a cell-wall distinct from the protoplasm. The cell composed of protoplasm bounded by a wall may be considered as occupying a step higher in the scale of organization. The generality of unicellular, or one-celled plants, however, are composed of such structures.

The size of the cell varies considerably. A bacterium cell may be so small as to require the highest powers of the microscope and the most accurate definition to determine its form; while it is still a matter of doubt if the branching tubes, filled with milky material, found in species of Euphorbia are not composed of a single cell. The hairs of many plants afford good instances of cells of large dimensions. Let anyone who cuts up an orange note the structure of the pulpy portion. A cursory examination will show him that it is built up of very large elongated cells, filled with a juicy material. These cells are the hairs of the inner wall of the fruit. And in no less a degree does the shape of the cell vary, as we shall see in our study of the tissues.

The truly vital portion of the plant and of the animal is the protoplasm. By its activity are all the parts of the body formed. The most complex plant and the most highly organized animal have had their origin in a small speck of protoplasm, and only so long as the protoplasm is alive can these be said to be living beings. The low power of a microscope reveals to us, in a drop of water taken from the bottom of a muddy pool, a small unicellular organism capable of locomotion and of alterating its form. It is known as an Amœba. Fig. 1 shows one of these animals in its various phases.

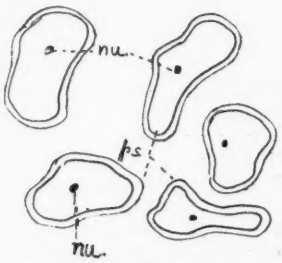



FIG. 1.—Diagrammatic representations of various phases assumed by an Amœba. The inner line indicates the boundary between the granular portion or endosarc, and the clear outer portion or ectosarc; *ps*, pseudopodia; *nu*, nucleus.

The processes marked *ps* can be sent out or retracted at will, and are called pseudopodia (ψευδος, false, and πους, a foot), or false feet. By the protrusion and retraction of these processes of its body the animal moves from place to place, and movement of this kind is very common in the two organic kingdoms, and is termed amœbiform movement. More careful examination reveals the fact that the outer portion of the body is clear and the inner granular. The granular parts are probably portions of matter about to be formed into protoplasm, or which have resulted from its decomposition. The mode of taking in food is also observed to be a very simple one. The animal encloses it by its false feet and absorbs it into itself; and its method of ridding itself of what it does not require, or cannot make use of for its nourishment, is no less complex—it ejects it at any spot on its surface. When it has grown large enough it breaks up into two pieces, and each portion so formed is a new Amœba, capable of performing the work which its parent previously did. All this can be seen very easily under the microscope. Amœbæ are not difficult to procure. For these reasons we have selected this animal to illustrate the work which a simple mass of protoplasm can perform. We see then that the phenomena of locomotion, nutrition (including ingestion, digestion of food, and ejection of waste products), and reproduction are all exhibited by this unicellular organism. To these we must add respiration, or breathing, the taking in of oxygen and giving out of carbon dioxide, which we know is also constantly going on during the lifetime of plants and animals.

In the higher plants the protoplasm is divided into pieces by walls, so that the whole organism consists of a number of chambers or cells. Each chamber in its young condition is filled with protoplasm; as they grow older the protoplasm in many cases disappears and leaves only the case in which it was contained, the cell-wall. The wall has not an origin apart from the protoplasm, but is deposited by the protoplasm itself. What we would

* Sachs' *Physiology of Plants*, page 73.

emphasize here is, that the protoplasm is the vital portion of the plant, and that from it all the parts of the plant are formed. Hence, in order to keep a plant alive, we must supply it with material containing the elements which enter into the constitution of protoplasm. Sachs speaks of "the universally known and yet essentially unknown protoplasm": it is *essentially* unknown, although, as the result of various chemical researches, its chemical composition has been roughly determined. Its chemical formula cannot be given, nor is this to be wondered at in the case of a body which is living, and hence probably constantly undergoing change. It is made up of proteids, complex compounds of oxygen, hydrogen, nitrogen, and sulphur, and when it is alive water is always present in it. If it be burned, these materials go off in the form of gas, but there remains behind an incombustible portion or ash, in which are present potassium, magnesium, calcium, phosphorus, and sulphur, in addition to other substances. All these elements—carbon, hydrogen, oxygen, nitrogen, sulphur, phosphorus, potassium, magnesium, and calcium—must be supplied in some form to a plant in order that it may live; for of these is its vital substance, or protoplasm, built up.

It remains for us now to determine in what manner these materials are taken in by a green plant, and what is their fate after absorption. The higher plants are those which are brought more immediately under our notice in our daily walks. We will, therefore, consider their method of feeding, premising, however, that it does not differ essentially from that of any green plant, however humble; but it will be useless to attempt a description of this until our readers have a clear notion of the structure of one of these. The remaining portion of this paper is thus devoted to an account of the anatomy of the elm tree—a typical dicotyledon.

It has a much branched root that it sends into the soil, and a stem branching in the air and bearing the leaves. The ultimate ramifications of the root are fine fibrils. These are its important portions. The tip of each rootlet is clothed with a cap (Fig. 2, *r.c.*), to prevent the growing tissue (*t*) situated immediately behind it from being damaged as the root pushes itself through the soil. As constantly as the outer layers of tissue are rubbed away, new ones, formed by the growing tissue, take their place. The root cap is thus being constantly renewed. At a slight distance behind the cap unicellular hairs are apparent. In a cross section of the root taken at this point it becomes evident that these are prolongations of some of the epidermal or outer skin cells (Fig. 3). The same figure shows the cortex or rind to be made up of iso-diametric cells containing protoplasm. The tissue they form is called parenchyma (παρα, and 'ενχυμα, a tube). Immediately beneath the cortex is the endodermis or bundle-sheath (ενδο, within, and δερμα, the skin) enclosing a zone of tissue composed of delicate cells, and called the pericycle. This in turn surrounds a mass of tissues forming the vascular bundle. The vascular bundle is a complex structure. It is composed of three chief portions—the xylem, phloëm, and cambium. The xylem (ξυλον, wood) or wood is made up of parenchyma, of elongated cells with walls spirally thickened and pitted (tracheides), and of vessels.

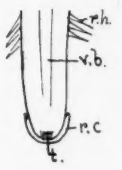



FIG. 2.—Diagrammatic longitudinal section of apex and front. *r.c.*, root cap; *t*, growing tissue; *v.b*, vascular bundle; *r.h.*, root hairs.

Vessels are formed by the fusion of cells placed end to end, whose adjacent walls have broken down. The tracheides and vessels contain no protoplasm. The cambium is composed of thin-walled cells densely filled with protoplasm. Parenchyma and sieve-tubes are the constituents of the phloëm. The sieve-tubes have received their name from the fact that their adjacent walls are provided with apertures giving them the appearance of a sieve, and sieve-plates are also at times present on their lateral walls. The xylem and phloëm alternate in position with each other, and the cambium is placed between, lying outside the xylem and inside the phloëm. The central portion of the root is occupied by the pith, which is formed of parenchyma. From the medulla or pith proceed rays of tissue—the medullary rays.

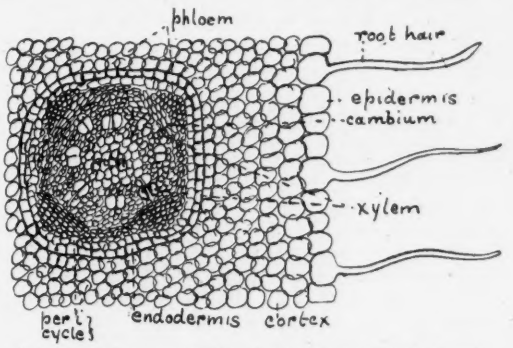



FIG. 3.—Transverse Section (semi-diagrammatic) of root.

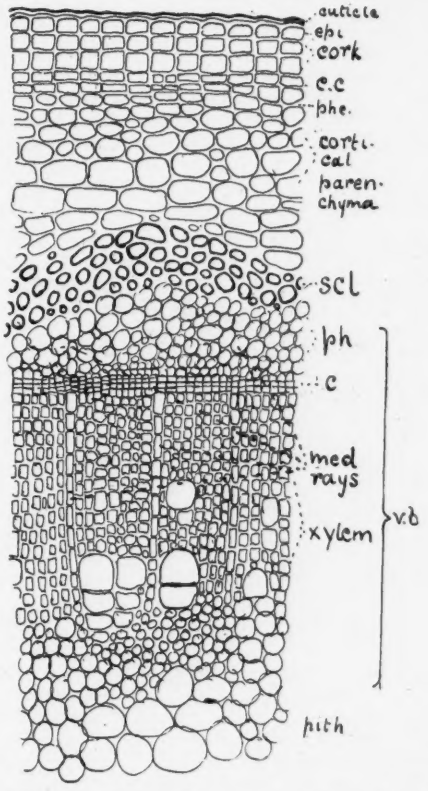



FIG. 4.—Transverse Section of young stem of Elm. *epi*, epidermis; *c c*, cork cambium; *phe.*, phelloderm; *scl.*, sclerenchyma; *ph.*, phloëm; *c.*, cambium; *med. rays*, medullary rays; *v. b.*, vascular bundles. The cork cambium forms cork towards the outside, and phelloderm towards the inside. The phelloderm at this stage contains chlorophyll. The large openings in the xylem are wood-vessels.

Fig. 4 shows a cross section of a young elm stem. We see that outside there is an epidermis (*epi.*) whose outer walls are covered by a layer impervious to water, and called the cuticle; a number of vascular bundles form a zone about midway between the centre and the periphery. In the centre is the pith, and outside the bundle zone is the cortex. The vascular bundles are essentially the same in structure as those of the root. The cortex is made up of large cells, the outer of which are filled with chlorophyll or green colouring matter. Outside each vascular bundle is a patch of tissue formed of elongated hard-walled cells destitute of protoplasm, and called *sclerenchyma* (*scl.*) (σκληρος, hard). Uniting the pith to the cortex, and cut by the cambium, run the medullary rays (*med. rays*). The xylem or wood lies next the pith, and the phloëm (*ph.*) next the cortex. The phloëm is sometimes called the soft bast or inner bark. The stem of a cabbage, left exposed for some time to the action of the elements, does not decay uniformly. The cortex and pith disappear and leave a framework composed of the vascular bundles. These are continuous with the bundles of the root.

The leaves are expansions of the stem. The green leaves, with which we are specially concerned at present, are of very varying forms, but the *anatomy* of the foliage leaf of the elm and of any other dicotyledon is practically the same. A continuous layer of cells surrounds the whole structure. This is called the epidermis (Fig. 5, *ep.*); it is covered by a continuous corky layer called the cuticle, just as in the epidermis of the stem. Towards the upper surface there are two or three layers of parenchyma which generally appear like a palisade (Fig. 5 *p.p*), and have hence received the name of palisade parenchyma. Below that lies a loose parenchyma tissue, the mesophyll, Fig. 5, *me.* (μεσος, the middle, and φυλλον, a leaf), with many spaces between the cells—inter-cellular spaces—and towards the lower epidermis there is a layer of roundish cells. The continuous epidermis of the stem and leaf is broken by numerous minute apertures—stomata (στωμα, a mouth)—whose structure and function were described in a previous paper in Knowledge for November, 1890, on the "Breathing Organs of Plants." There it was stated that these little mouths are not breathing organs, but are the structures which regulate the giving off of water by the plant; they are the *transpiring* organs.

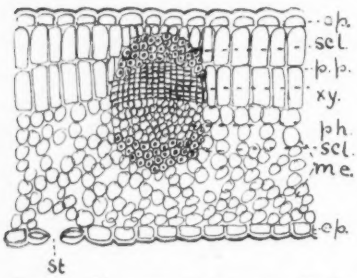



Fig. 5.—Diagrammatic transverse Section of Leaf. *ep.*, epidermis; *scl.*, sclerenchyma; *p.p.*, palisade parenchyma; *xy.*, xylem; *ph.*, phloëm; *me.*, mesophyll; *st.*, stoma. The black dot in the centre of the sclerenchyma cells represents the cavity of the cells.

A section of a leaf taken through a vein at once shows that this is merely a vascular bundle. Its course can easily be traced by dissection from the leaf blade, down the leaf stalk or petiole, to the bundles of the stem. The veins are the ultimate ramifications of these organs, but differ from them in not containing cambium.* The xylem is in consequence at the upper surface and the phloëm towards the under surface of the leaf blade. A sclerenchymatous sheath (*scl.*) more or less completely surrounds each bundle, adding strength to the structure. The mesophyll and palisade parenchyma are packed with chlorophyll granules. With the exception of the guard cells of the stomata there is no chlorophyll in the epidermis.

We close this paper by alluding to a few interesting facts in connection with the structure of this plant, which we will not have occasion to speak of afterwards. In the root we saw the pericycle, a layer of tissue which surrounds the vascular bundle. It has a very definite work to perform. When a young root is to be developed the cells of the pericycle situated opposite a xylem tract become active, divide up and give origin to the young root which breaks its way through the outer tissues of the parent root. The cambium of the vascular bundle of the stem and root becomes active in spring, and continues so during summer and early autumn; its cells divide up to form on the outside phloëm and on the inside wood or xylem. In a two or three year old twig of the elm or other tree we find a mass of *wood* in the centre, and in the spring we can easily strip off the bark. The juicy portion which immediately surrounds the wood left is the ruptured cambium, whose delicate texture enabled the operation to be performed so easily. The wood increases much in excess of the phloëm. This can be seen by examining the stump of a recently felled tree, such as the elm or oak. The pith has not a long existence; it soon becomes obliterated by the growth of the xylem. In the hemlock, and generally in the Umbelliferæ, the group of plants to which it belongs, the pith breaks down and the centre of the stem is occupied by a large cavity, interrupted at the nodes or parts where the leaves come off. The epidermis of a forest tree is soon shed, and its place is taken by a corky tissue (Fig. 4), formed from a layer of cells in proximity to the epidermis. This in turn is thrown off, and is replaced by a cork layer formed in a similar manner.

* In a monocotyledon, such as a palm or grass, the vascular bundles of the stem are not arranged in the manner stated, but are disposed irregularly; moreover, they are *closed* bundles, that is, they possess no cambium.

## SOME FACTS ABOUT EXPLOSIVES.

By Vaughan Cornish, B.Sc., F.C.S.

THE general phenomena of explosion are well known: noise, shock, resistance offered and overcome, and, in general, some work of destruction wrought, such as demolition of a structure or the disruption of a rock.

Various materials, solid and liquid, are employed for the purpose of producing and utilizing the effects of explosion. Every such material is termed an *explosive*, although sometimes, as in the case of gunpowder, the material is in fact a mixture of several substances; coal gas and fire-damp are not called explosives, although on mixing with air they are capable of exploding. An explosive proper contains its own supply of oxygen.

Explosives are of two principal kinds, of which gunpowder and gun-cotton are typical examples. Gunpowder is a mixture of three different chemical substances, whereas gun-cotton (and similarly the other nitro-explosives, as, *e.g.*, nitro-glycerin) is a single chemical substance, composed, however, of several elements, one of these elements being oxygen.

In gunpowder we very intimately mix together two substances, charcoal and sulphur, which are capable of combining chemically with the oxygen contained in the third substance, nitre. All that is necessary to bring about this chemical change is, firstly, that the particles of the various substances shall be brought very close together, which is effected by the careful incorporation of the ingredients; and, secondly, that the temperature should be high. At a

high temperature gunpowder takes fire, or, if the conditions be suitable, explodes. In the combustion of gunpowder the carbon burns to carbonic acid (a gas), the sulphur burns to sulphurous acid (a gas), and other gaseous products are also formed in considerable quantity.

The heat developed by the chemical reaction raises the temperature of the gases, which causes them to expand rapidly and occupy a large volume. If the burning of the gunpowder takes place in a confined space, the force of expansion of the gas is resisted by the walls of the enclosure, and if the latter are not of sufficient strength, the obstacles are overthrown. If, however, the enclosure be sufficiently strong and furnished with no outlet (as in certain experiments where very small charges are fired inside strong bombs), the gases formed are kept compressed in a small volume, and no disruption takes place.

Here we have the fact of explosion, without its usual striking accompaniments.

When a cartridge is fired in a gun-barrel, the gases, whose force of expansion would be sufficient to burst the steel of the barrel, find in one direction no great resistance, and expanding rapidly in this direction propel before them the bullet, which thus leaves the muzzle of the gun endowed with a high velocity.

Explosives are compounds or mixtures, which contain in themselves elements capable of taking up a new molecular arrangement forming fresh compounds, one or more of the new compounds being gases, and the formation of these compounds being accompanied by an evolution of heat. The formation of gases, and the development of heat in the reaction, are essential to the production of an explosion.

When we come to enquire what is the condition generally necessary to produce the explosion of an explosive body, we find that it is the rapid vibration of the particles. Such vibration may be generated by heat, by shock, or by friction, but in general the condition most favourable to explosion is one of rapid vibration, which may be produced by a sudden blow which will serve to detonate dynamite without appreciably heating it. The liability of the occurrence of explosion under such circumstances does not depend only on the *force* of the blow, but on the nature of the striking body with which the blow is given. Thus, a force of blow which would cause explosion if the blow were one of steel against steel might be harmless if produced by wood against wood. In this case the explosion is determined, not by the amount of heat produced, but by the rapidity of the vibration. It is well known that a tuning-fork struck against steel yields a higher note (*i.e.*, a sound of more rapid vibration) than if struck against wood.

When explosion occurs the chemical atoms are *shaken out* of one combination to fall into another. This process takes place much more readily when the explosive is warm.

Although explosions are often produced independently of heating effects, yet it must be borne in mind that at a sufficiently high temperature all explosives will detonate.

In the study of phenomena connected with explosives we often meet with occurrences at variance with the old dog-Latin dogma, *causa æquat effectum*. The pulling of the trigger, followed by the rush of the bullet from the gun, is a familiar example; the work done in pulling bears no proportion to the energy developed by the explosion. Another case in point is afforded by the manner in which explosions are sometimes caused in the incorporating mills, in which the component materials of gunpowder are mixed together. The presence of a small hard body, such as a nail, or even a hard piece of grit, may cause sufficient local heating to start an explosion of the whole mass. Both shocks and local heating are most carefully guarded against in gunpowder factories. Charcoal possesses a property (that of condensing air in its pores) which sometimes leads to local heating and induces spontaneous combustion.

In grinding the sulphur there is another source of danger. Sulphur is a highly electric body, and in the process of grinding a large amount of electricity will often accumulate, sometimes giving rise to sparks, the passing of which may produce serious consequences. The danger from this source is, however, to a great extent overcome by connecting the sulphur mills to earth by means of copper wires, and thus continually drawing off the charge of electricity produced by friction in the grinding process.

In the pressing of the gunpowder, hydraulic machines furnished with ebonite plates are frequently employed. Ebonite is a convenient material for the purpose, being tough, elastic, smooth, and sufficiently hard. Unfortunately, ebonite is a highly electric material, and the upper and lower plate, with the cake of powder between them, form practically an electric pile. A passing thunderstorm may induce a discharge of sparks from the ebonite, igniting the gunpowder and producing, as has happened in several cases, fatal accidents.

In spite of all precautions, explosions are liable to occur in the mixing of the materials for gunpowder, and it is well to provide, as far as possible, for the safety of the *employés* and of the building. A good protector for the workmen is a curtain of ships' hawsers, which offer the kind of resistance which is most effectual in the case of an explosive outburst of gas.

By having a light roof, secured only by one or two wooden pins, an outlet is obtained for the gases produced in a factory explosion. The roof is simply lifted off, and the outlet thus given prevents the pressure inside the building from becoming sufficiently great to damage seriously the main portions of the building.

Turning now from the explosive *mixture* gunpowder to the nitro *compounds*, such as gun-cotton and nitro-glycerin, we find that the nitro bodies explode more readily under shock, and also at a lower temperature. Nevertheless, in the hands of properly-trained workmen, the manufacture of nitro-glycerin and dynamite is accompanied by fewer casualties than that of gunpowder. Gun-cotton is prepared by the action of strong nitric acid and sulphuric acid upon cotton-wool. Most of the processes are carried out in presence of a large excess of water, though this is, of course, not the case during compression, in which operation great care has to be exercised.

Nitro-glycerin, prepared by acting upon glycerin with a mixture of nitric and sulphuric acids, is liable to explode both by heat and by shock.

Dynamite is produced by absorbing three parts of nitro-glycerin by one part of kiesulguhr, a finely-divided siliceous earth capable of absorbing a large quantity of liquid without becoming pasty. Dynamite only explodes when subjected to special treatment, being unaffected by moderate heat or by an ordinary blow, but detonating under the sharp shock given by a percussion fuse of fulminating mercury. The kiesulguhr plays no part in the actual explosion, so that dynamite, as an explosive, must be classed along with gun-cotton and the other *compounds*, rather than with explosive *mixtures* such as gunpowder.

The smokeless gunpowders now coming into general use are prepared from gun-cotton, or from gun-cotton and nitro-glycerin.

A special class of explosives are required for filling percussion caps and detonators. Fulminate of mercury is the most important of these highly dangerous substances, the

manufacture of which is conducted with the most elaborate precautions, not only against shock, but against the smallest amount of friction.

The protection of factories against lightning is a problem of considerable difficulty. According to Mr. Otto Guttmann, whose recent paper before the Society of Chemical Industry contains much useful information on this and other matters connected with the dangers of explosives, a system similar to that of Professor Lodge's "network" protector has been extensively and successfully used by Austrian military authorities. The system is similar to that by which electrometers are shielded from electrification by means of a wire cage, the building being covered by a network of galvanized iron wire. This material is, of course, much cheaper than copper, and its smaller electric conductivity does not appear to be a serious drawback in the case of electric discharges of such high potential as that of lightning.

## RADIOMETRY.

By A. JAMESON.

THE kinetic or, as it is sometimes called, the molecular theory of matter, by which its sensible qualities are referred to the motion of atomic and molecular parts, and the undulatory theory of light, which asserts that radiation is due to transverse waves in a medium with which all space is filled, have become thoroughly incorporated with modern physical science. Employed in the first place as working hypotheses, these theories have gradually become established as truths. To give anything approaching a complete exposition of them would be a most extensive undertaking. But, without pretending to this, it is thought that a discussion of some few typical instances in which the operations of these laws have been recognised may prove interesting.

Prof. Crookes' radiometer, or light mill, furnishes a remarkable example of the conversion of energy in the form of ethereal waves into molecular and subsequently molar motion. The commonest form of radiometer is shown in Fig. 1. Four light vanes of mica, attached to radial wire arms, are fixed to a central cup, that is balanced, like that of a compass needle, upon a fine steel point. One side of each vane or paddle is painted a dull black with lampblack; and it is upon these lampblacked faces of the vanes that molecular pressure, resulting from radiation, will be exerted. A small glass tube is fixed vertically over the central pivot cup. In the position shown this tube is free from contact with the fly, but serves, should the instrument be inverted, to prevent it from toppling off the needle-point. The glass bulb, having been highly exhausted by a mercury pump, is hermetically sealed.

FIG. 1.

Remembering that what we call heat is simply a state of vibration of the molecular parts of bodies—restricted in the case of solids and liquids, extending to perfectly free excursions in the case of gases—we will proceed to consider the effect of radiation, as, for instance, of diffused daylight, upon the piece of apparatus just described. Light traverses the glass envelope freely, because, as we may assume, there is no correspondence between the periods of the luminous waves and those of the molecular vibrations in glass. With the lampblacked surfaces of the vanes, however, the case is very different. Here the periods of the vibrations accord so nearly with those of waves of light that complete absorption takes place before an appreciable thickness of the substance has been penetrated. Just as the swing of a pendulum is amplified by properly timed impulses, so the swing of a molecule responds to transverse ether waves of suitable frequency; and light waves are quenched by the lampblack in consequence of the conversion of their energy into molecular motion, that is to say, heat. Mica, like glass, and like most gases, is a transparent substance, whence it follows that light falling upon the clear surfaces of the vanes will also be transmitted to the layers of lampblack, and by them absorbed, with corresponding elevation of their temperatures. So little absorption takes place in mica that practically all light falling on the bright sides of the vanes is either transmitted as described or is reflected. But, in some instruments, the mica surfaces are coated with a bright metallic film, and in such cases, excepting only at the blackened parts, nearly all of the incident light will be reflected. Where light is not absorbed, of course it cannot be the source of heat; and therefore no increase of temperature, corresponding to that which takes place in the lampblack, can occur at the polished surfaces of the vanes. Undoubtedly some heat will be *conducted* through the mica from the blackened to the polished side; but since this material is an extremely bad conductor, the amount of heat thus transmitted must be small. On the other hand, heat will pass rapidly from the warmed lampblack to the air or other gas with which it may be in contact; and it will presently be shown to be this kind of transference of heat that accounts for the rotation of the light mill.

To make this matter clear we will suppose, in the first place, that the glass bulb contains gas at the ordinary pressure of the atmosphere, and we will confine our attention to one only of the four similar and similarly situated mica vanes. As the molecular vibrations at the surface of a solid body, such as lampblack, will take place with most freedom when normal to that surface, we may expect every gas molecule that strikes the warmed face of the vane to be thrown back in some direction, making a smaller angle with the perpendicular than does the direction of incidence. Thus the lampblack will give rise to a "molecular wind," made up of gas molecules whose paths are, upon the average, nearly perpendicular to the heated surface. But the mean free path of gaseous molecules at the normal temperature and pressure is extremely small. It is estimated by Maxwell, in the case of hydrogen, at 965 meter tenths (say $\frac{1}{10000}$ mm.), in the case of oxygen and of carbonic acid at 560 and 430 meter tenths* respectively. Hence the molecules rebounding from the heated surface will encounter others, and will thereby have the direction of their motion altered many times before they travel an appreciable distance; and hence the extra speed acquired by the gas molecules by collision with the hot lampblack—the extra temperature, in other words, of these free molecules—will be diffused in every direction through the atmosphere within the bulb. Now, since the blackened surface of our vane is bombarded by molecules having an average velocity corresponding to (say) 15° (or whatever may be the initial temperature of the instrument) and since these molecules are thrown off again with an average velocity corresponding to (say) 15·1°, it might be thought that molecular pressure should be developed, even in the circumstance we have supposed, that is, in gas at the normal pressure of the atmosphere. For action and reaction must be equal and opposite; and

* 1 m. tenth = 1 m. $\times 10^{-10}$

provided the same number of molecules per second struck the warm and the cold face of the vane, it is certain that the additional work of repulsion done upon them at the former surface would react upon the vane itself, and drive it in the opposite direction from the shower of heated molecules. As a matter of fact, however, this does *not* take place; for the density of the gas in that thin heated layer, contiguous to the lampblacked surface, is less in proportion as its temperature is higher than in any other part of the bulb. The quickened molecules, shooting away from the lampblack, beat back a proportion of those that move more slowly; and thus the number of impacts on the heated surface is reduced, and the equilibrium of the two sides of the vane is almost perfectly maintained.

Next consider the effect of exhausting the glass bulb of the radiometer. The mean free path of the gas molecules will increase directly with the exhaustion, while the average distance from centre to centre of the molecules will only increase with its cube root. Hence, by a sufficient degree of rarefaction, the free path can be made quite considerable, though the molecules are still crowded together in enormous number. At an exhaustion of one-millionth of an atmosphere, the free path will be a million times augmented—that is, to a length of about ten centimetres—and it is under pressures ranging from this point up to about fifty-millionths of that of the atmosphere that light mills exhibit the highest efficiency. As exhaustion of the bulb is carried out, new conditions of cooling begin to manifest themselves before the heated lampblack. As the free path increases, the "molecular wind" that has been spoken of blows further, and cooler particles of gas crowd in upon the blackened surface from the sides. By-and-by the shower of molecules (moving at a velocity corresponding to 15·1°, and in a direction normal to the surface of the vane) will extend to the glass envelope, and will communicate their heat to it directly. Comparatively few will now collide with the colder molecules travelling in the opposite direction; and these colder molecules, no longer unduly checked in their journeys to the blackened surface, encounter it as often as they do the other side. The *reaction*, or Crookes' pressure, at the warmed surface will therefore assert itself, and occasion the rotation of the fly.

When first the radiometer was exhibited, it was suggested that the sunny side of the earth would suffer a force of repulsion comparable with that upon the vane of such an instrument. It is almost unnecessary to say, however, that there is no foundation for this idea in the now accepted explanation of Prof. Crookes' discovery. Crookes' pressure is only indirectly due to radiation, and it is quite distinct from that estimated by Maxwell (see his *Electricity and Magnetism*, vol. ii., p. 402) at about $2\frac{1}{2}$ lbs. per square mile of the sunlit surface of the earth.

FIG. 2.

Prof. Crookes' mechanism is applicable to the conversion of radiant energy, of probably almost any wave length, into a form convenient for approximate measurement. But, from the definition that has been given of absorption, it follows that the layers of lampblack on the vanes may have to be replaced by various other materials, according to the quality of the radiation that it is desired to measure. Radiometers sensitive to actinism and to radiant heat have been constructed, and it may be presumed that such instruments can also be made to respond to the electrical radiations that have been studied by Prof. Lodge and others.

The constructive details of the apparatus can be modified in very many ways. For instance, a fly having several plain mica vanes, skewed like the blades of a screw propellor, may be placed in the path of the shower of molecules proceeding from a fixed disc of lampblacked material. In consequence of the favourable situation of the reacting surfaces, very rapid rotation takes place in this modification of the radiometer. It has been named by Prof. Crookes the otheoscope, and is shown in Fig. 2. If the skewed vanes of the otheoscope could be rotated sufficiently rapidly by mechanical means, a stream of molecules would be generated, not unlike that which is set up by the heating of the lampblacked disc. The study of molecular motion under such conditions is not without practical interest. Indeed, with every different point of view from which the radiometer can be regarded, some attractive suggestion presents itself.

## Chess Column.

By C. D. LOCOCK, B.A.Oxon.

ALL COMMUNICATIONS for this column should be addressed to the "CHESS EDITOR, *Knowledge Office*," and posted before the 10th of each month.

*Solution of June Problem* (by C. D. Locock).—1. Q to R5, and mates next move.

CORRECT SOLUTIONS received from Alpha and C. T. Blanshard.

*H. S. Brandreth.*—If 1. Q to B5, Black replies P × R, or Kt to K6, and no mate results.

*J. C. Knocker.*—There is a flaw in your conclusion. After 1. Q × P, Black provides an escape for his King by Kt to K6.

*C. Leeson Prince.*—After 1. Q × Ktch there is no mate.

*Alpha.*—"Dummy Pawns," as they are called, are no longer allowed. There is also a prejudice against any promotion on the first move, just as there is against checks and captures.

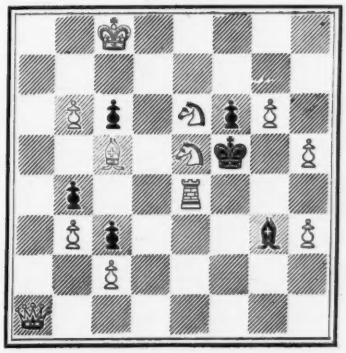
*C. T. Blanshard.*—Thanks for the Problems. The promotion problem is a little too simple, apart from the fact that RP becomes a Queen is equally effective. The other seems all right. The three-mover is neatly solved in one move. In the variation you give the Rook and not the Bishop mates. Perhaps the diagram was wrong.

### PROBLEM.

By J. JUCHLY, Munich.

(From the *Field*.)

BLACK.



WHITE.

White mates in three moves.

We fully endorse a statement in the *Hackney Mercury* as to the difficulty of the above. The chief difficulty lies

in finding defences against other key-moves than the correct one.

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Consultation Game played at the Boston Chess Club, on the 8th April, by W. Steinitz against Messrs. J. F. Barry, C. B. Snow, and H. N. Pillsbury. The score is from the *Liverpool Mercury*.

[KING'S GAMBIT DECLINED.]

| Steinitz. | Allies. |
|---|---|
| 1. P to K4 | 1. P to K4 |
| 2. P to KB4 | 2. B to B4 |
| 3. KKt to B3 | 3. P to Q3 |
| 4. B to B4 (*a*) | 4. QKt to B3 |
| 5. P to B3 | 5. Kt to B3 |
| 6. Q to K2 | 6. Q to K2 (*b*) |
| 7. P to Q3 | 7. B to KKt5 |
| 8. P to B5 (?) | 8. Castles, QR |
| 9. P to Kt4 (*c*) | 9. B × Kt |
| 10. P × B (*d*) | 10. P to Q4 |
| 11. P × P (*e*) | 11. Kt × QKtP (*f*) |
| 12. P to Q4 | 12. B to Kt3 |
| 13. B to R3 | 13. KKt × P |
| 14. Q to K4 (*g*) | 14. Kt × QBP ! |
| 15. Kt × Kt | 15. R × P |
| 16. Q to K2 | 16. Q to R5ch |
| 17. K to Bsq | 17. R × B |
| 18. B × Kt (*h*) | 18. R × B |
| 19. Kt to K4 | 19. R to Qsq |
| 20. K to Kt2 (*i*) | 20. R × Kt ! |
| 21. P × R | 21. R to Q7 (*j*) |
| 22. Q × R | 22. Q to Kt5ch |
| 23. K to Bsq | 23. Q to B6ch |
| 24. K to Ksq | 24. Q × Rch |
| 25. K to K2 | 25. Q × R |
| 26. Resigns. | |

NOTES.

(*a*) 4. Kt to B3 is at least equally good. 4. P to B3 may also be played.

(*b*) With a view to castling on the Queen's side if desirable.

(*c*) Premature, as Black's excellent play demonstrates; but in any case his centre must be broken up by P to Q4.

(*d*) If 10. Q × B, Kt × KtP; 11. P × Kt, B to Q5, &c.

(*e*) Messrs. Pillsbury and Barry, in their notes to this game, suggest as an alternative 11. B to Kt3, Kt × KtP; 12. P × Kt, B to Q5; 13. B to Kt2, Q × P ch.; K to Bsq, Kt to R4; with a strong attack. The position after these moves is most remarkable, White having scarcely a move which he can make without loss. Perhaps, therefore, his safest course at move 11, was simply 11. P × B, P × B; 12. P × P, Q × P; 13. B to K3, Q to R4; 14. Castles, with fair prospects of ultimate safety.

(*f*) A very ingenious sacrifice. If the Knight be taken, Black clearly wins back the piece by 12. . . . B to Q5.

(*g*) Overlooking Black's crushing reply. But even after 14. B × KKt, Q to R5ch; 15. K to Bsq, Kt × B, he would have a very bad game.

(*h*) If 18. Kt to K4 at once. Black wins by 18 . . . R to B7, for the Knight must cover.

(*i*) Black ~~threatened to win a piece by~~ R × Kt and Q to R6ch, &c. 20. Kt to Kt3 is useless on account of 20 . . . Q to Q5 and 21. . . . R to Kt7.

(*j*) A beautiful final coup which wins a clear Rook. Black's play throughout against their formidable opponent has been of the very highest order. The innovation of castling on the Queen's side turned out most successfully.

## CHESS INTELLIGENCE.

The American Championship Match was concluded last month, the final score being Lipschütz, 7; Showalter, 1; drawn, 7. Mr. Showalter is well known as a rising, and at times a brilliant player, but in the present match the brilliancy seems to have deserted him. Nor are his previous performances in any way to be compared with those of his opponent, who is evidently in America second only to Mr. Steinitz. The large proportion of drawn games is noticeable.

The *Hackney Mercury* announces an Autumn Problem Tourney. Entries to be sent in by September 1st. Under certain conditions corrected versions of previously published unsound problems will be admitted. There are two sections (for two-move and three-move direct mates respectively), and four prizes in each section. Composers are limited to one problem in each section.

The Divan Handicap has again been won by Mr. F. J. Lee, with the good score of 12½ out of a possible 16. Mr. Mollard (Hon. Sec. of the South Norwood Chess Club) was second, with 11½. Mr. Loman, who made such a fine score against the rest of the first class that his ultimate victory was looked on as assured, failed signally as a giver of large odds; his last game gave Dr. Alderson his solitary victim.

The long-expected match at the British Chess Club, between Messrs. Blackburne and Lasker, ended in a decisive victory for the young German master by 6 games to 0, with 4 games drawn. This performance, coming as it does after his two previous tournament successes, seems to settle the Championship of England question probably for some time to come. Possibly Mr. Blackburne was not at his best throughout, notwithstanding his splendid combination in the middle of the ninth game. Mr. Lasker's play is not always intelligible to the general public; in the words of Mr. Bird, he is "a very mysterious player." Perhaps the mystery is partly explained by the fact that when he sees nothing to do he is content to do it. Bold and unexpected Pawn-play is his speciality. Probably altogether he has no equal in Europe except Dr. Tarrasch.

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